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Sky and TELESCOPE

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The aurora borealis

Dance of the Dead

DANCE OF THE DEAD might entitle the front-cover picture this month, if we follow the suggestion of Verne W. Thompson, of Stamford, Conn., who took this picture of the aurora borealis display of August 12, 1939. In sending it to us, he writes:

"There is an old Indian legend regarding this sky phenomenon which reads as follows (taken from **Myths of the New World,** by Daniel G. Brinton): 'So the Eskimo of the distant north, in the long winter nights, when the Aurora bridges the sky, with its changing hues and arrowy shafts of lights, believes he sees the spirits of his ancestors clothed in celestial raiment, disporting themselves in the absence of the sun, and calls the phenomenon the Dance of the Dead.'

"It was my wish to get some kind of an effect that would suggest the dance, and to me this picture does have this feeling. If you will hold it so the left-hand side is at the bottom, and use a little imagination, a figure can be seen that appears to be dancing, and to me resembles very much what I would expect a spirit to look like.

"I made three exposures before the figure moved enough to blur the picture. The best was about eight seconds at f/3.5 on what is considered slow film, Eastman Plus X, which is rated at 50 Weston. No tripod was used, as in a case of this kind it can be a nuisance; I press the camera against a solid post or use the ground for more vertical shots, with a stone slipped under the camera to point it in the proper direction.

"Most important, however, is always to have a film in the camera. My friends on this night all flocked over to my house on the run as they all knew of my interest in the sky, and principally because I have a fairly good 6-inch reflector that I built several years ago, but to my mind this was a night for the camera. I had taken several exposures, but my camera shutter wind, which also transports the film, didn't feel just right and suddenly I realized I had no film in the camera. All I said was, 'Well, that is that,' just as if I had used up a roll, rushed into the house and hastily put in a film!

"I use for all my pictures 35-mm. film and make my prints on chlorobromide paper, as this paper tones very nicely for brown or blue. The blue tone I like very much, as it is a kind of atmospheric blue and is made up and kept in stock in three 8-ounce bottles of water, one containing 50 grains of citric acid, one containing 15 grains of gold chloride, and the third containing 50 grains of thiocarbamide. One ounce of each added to 10 ounces of water will tone a well-washed print in about 15 minutes. If the print is overexposed at least 10 per cent, and underdeveloped, the contrast will be raised about 10 times in the finished print."

Mr. Thompson's 11 by 14 enlargement does convey the "atmospheric blue" he mentions, although this is lost, of course, in making the black-and-white cover picture.

Sky and TELESCOPE

The Editors Note . .

STELLAFANE was a great success this year. The enthusiasm of amateur telescope makers has not been lessened by the five-year lapse since they previously gathered on Breezy Hill, near the thriving town of Springfield, Vermont. A three-day storm passed off just in time to assure good weather; Russell W. Porter was there; and more than 300 persons convened at the chalet-type cottage and turret-type telescope which give that spot a unique appearance fitting with its unusual traditions.

Stellafane is a convention without sessions. Everyone has ample time to converse with his fellow hobbyists and to make the acquaintance of all who come from far and near. The crowd is very heterogeneous, and includes those who like to sit and talk, those who like to stand and talk, and others who like to flit from telescope to telescope. At dusk, queues form for observations of the moon, which always manages to be near first quarter for Stellafane. Rarely does our satellite fail to appear for early-evening tests of the many telescopes of all ranges of size and type which dot that Vermont hillside. At the conclusion of the evening's talks — the "formal" part of the program — these same instruments are manned far into the night, many of them all night long if the observing conditions are perfect.

The gastronomical interest is satisfied by a huge feast under open tents, topped off by corn-on-the-cob and pie-a-la-mode. (After the first visit to Stellafane, one goes easy on the first courses of the banquet in anticipation of these last two items.) The Springfield amateurs have lost none of their facility for handling the large crowd. Theirs is a voluntary undertaking, to be sure, but they deserve special expressions of gratitude for the heavy burden of paper work, planning, and physical labor which this event imposes on them each year.

As darkness falls, everyone finds a seat on terrace, turf, or stone, and listens to short talks by the notables present, led

(*Continued on page* 17)

VOL. V, NO. 11
WHOLE NUMBER 59

CONTENTS

SEPTEMBER, 1946

COVER: A photograph of the aurora of August 12, 1939, taken by Verne W. Thompson, of Stamford, Conn. See "Dance of the Dead."

BACK COVER: A portion of the moon near first quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. The reproduction is reduced 10 to 7 from a 7.8 enlargement of the original negative. (See In Focus.)

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The Beauty and Mystery of the Northern Lights

By W. Carl Rufus, *University of Michigan*

THE BEAUTY and variety of forms and colors, quiet glows and illusive motions, bright concentrations and illuminations covering the entire sky, combine to make a great auroral display one of nature's grandest and most awe-inspiring extemporaneous events. Spectators agree that artists cannot depict the lively beauty on a quiet canvas. Photographic plates may record details, but not the widespread grandeur. A colored motion picture of the entire sky on the inner surface of a hemispherical dome would be required to do faint justice to this masterpiece of nature.

The polar arc with radial rays is the most common type. Variants occur, however, such as incomplete or double arcs, some without rays, others with rays either radial or parallel. Magic beams and flashes, alternately appearing and disappearing, arise usually from the northern half of the horizon. Tremulous rays send pulses upward, probably real, with motions so rapid that they seem illusive. Sometimes there is even a peculiar cross motion. The corona, or aurora glory, may appear merely as a whorl of light at the magnetic zenith, south of the northern observer's zenith, or it may be accompanied by colored beams extending to all points of the compass. Irregular bands occasionally stretch across the sky from east to west, moving fitfully but majestically, usually toward the south.

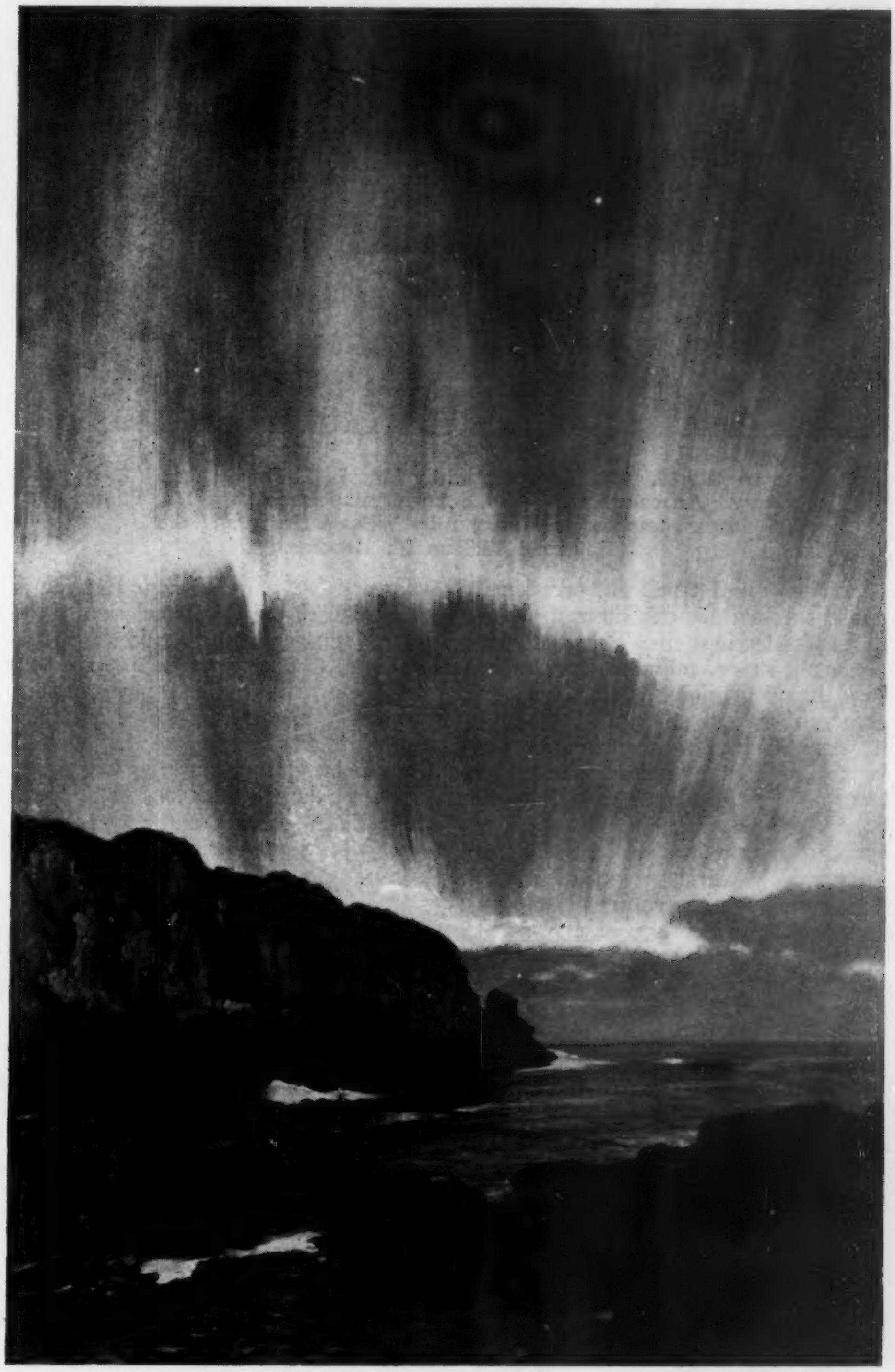
Various forms, including curtains, draperies, luminous clouds, diffuse glows and "merry dancers," enhanced by mingled tints of green, yellow, aurora orange, and deeper reds, sometimes with rapidly changing forms and colors, captivate the fortunate observers when nature puts on a special exhibition.

Faint luminosities are nearly white; fairly bright ones are yellowish; other colors, especially green and red, also occur quite frequently. The colors of the rainbow seem inadequate to describe all the tints and shades seen by different observers. The following terms are gleaned from various sources: red, blood red, fiery red, aurora red, red rose, damask rose, pink, rose pink, orange, crimson, bright crimson, deep crimson, carmine, brilliant carmine, gold, yellow, pale yellow, blue, green, bright green, dark green, emerald green, purple, soft purple, violet, white, creamy white, silvery white, silver gray, grayish-white, and, strange to relate, black is not lacking. Some displays at night cast shadows and others are sufficiently luminous to be seen in the daytime.

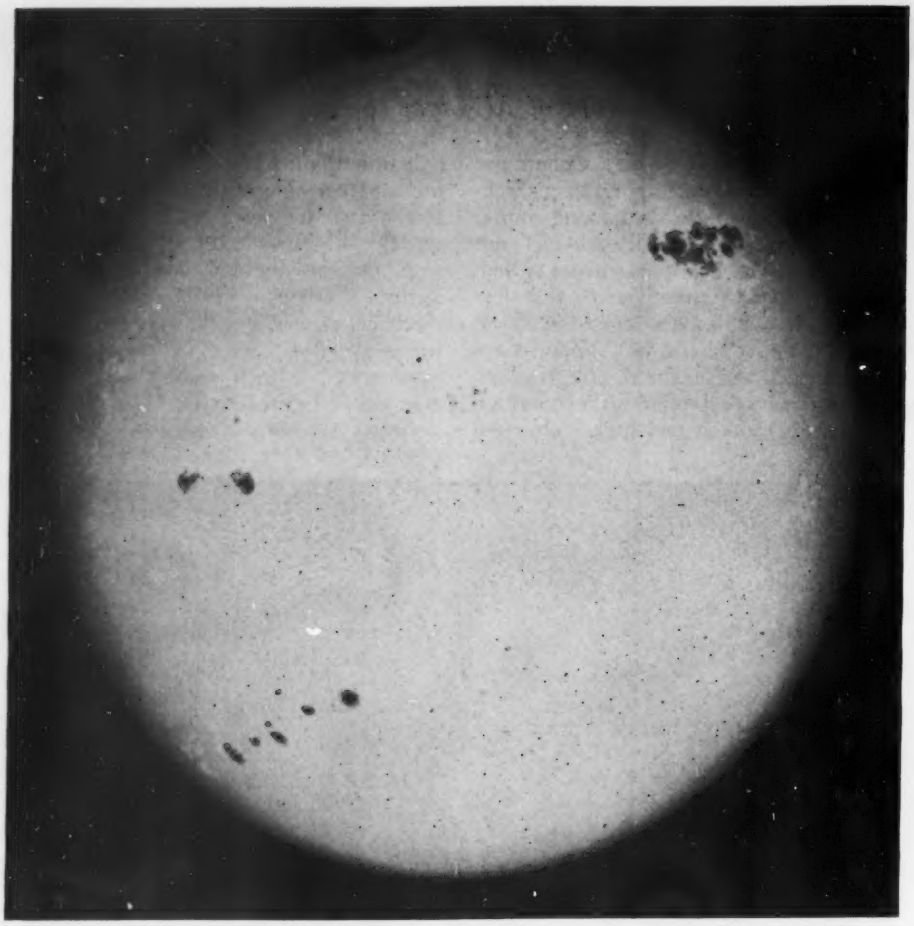
Auroras have also been heard, according to a number of reports, chiefly in high latitudes. The sound has been described as "a hissing, cracking, and rushing noise through the air, as if the largest fireworks were playing off." Others use similar terms — a rustling noise, a crackling sound, a hissing or whizzing sound. And passing strange, auroras can not only be seen and heard, but also smelled, according to accounts given by travelers in Norway. One such is quoted in *Aurorae and Their Spectra,* by J. Rand Capron, from its source, the *Arctic Manual.* An "aeronaut, descended on a mountain in Norway 1300 metres high," observed a brilliant aurora, accompanied by "an incomprehensible muttering . . . ; when this ceased he perceived a very strong smell of sulphur, almost suffocating him."

It remains for someone to taste the aurora. Perhaps it has been felt, as some electrical experiments have been more-or-less successful. Some people may have experienced it with a sixth sense, but a scientist is limited to five.

Not every aurora displays all of the



An auroral display observed on the coast of Maine, and painted in oil by Howard Russell Butler. Courtesy, American Museum of Natural History.



The sun on July 30, 1946, photographed by Mrs. L. T. Day at the U. S. Naval Observatory. An enlargement of the huge group is on page 11. Photos of these spots were also sent in by William Henry and the Reverend William M. Kearons.

various classified types, but occasionally a very unusual one exhibits many forms during its development. The usual order of the phenomena follows: glows, arches, rays, luminous clouds, flashes, curtains, coronas, bands.

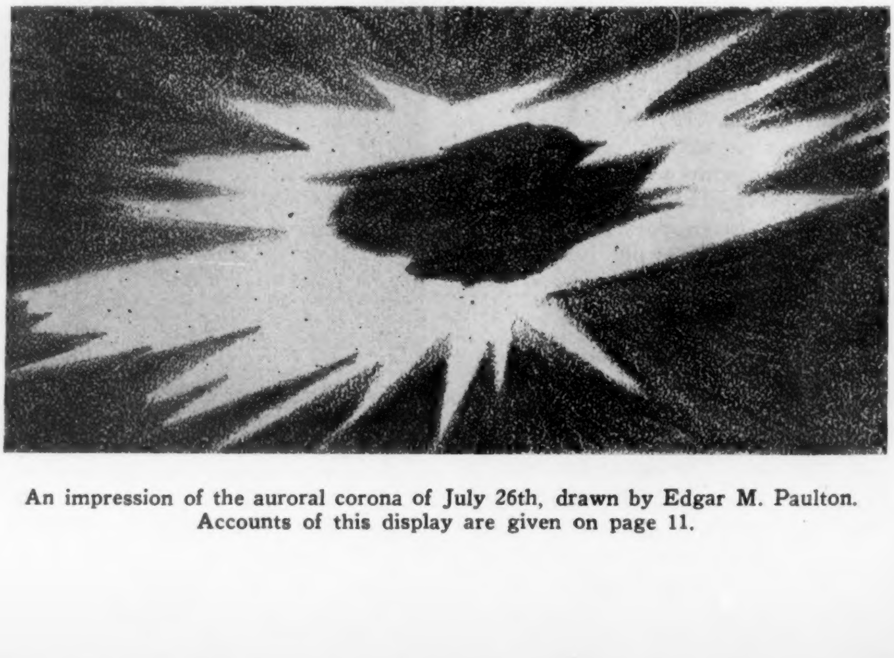
Many theories of the cause of the aurora have been proposed since the cohorts of Tiberius Caesar rushed presumably to the aid of flaming Ostia, only to find that the sky was ablaze, and Seneca described the various types of celestial fire. From our 20th-century pinnacle, we look back with poorly concealed amusement at some attempted explanations, which we kindly omit. Halley proposed the circulation of magnetic effluvia of the earth from one pole to the other. Euler advocated that luminous particles of the earth's atmosphere were driven to great heights by the light of the sun. Benjamin Franklin, whose kite captured electricity from a flash of lightning, attributed the aurora to electrical fire kindled as vapors of the tropics passed to the polar regions.

Many solar phenomena are closely related to sunspot activity and vary with its 11-year periodicity, for instance, the latitude of spots, the number of faculae, flocculi, and prominences, the form and activity of the sun's corona, and the intensity of solar radiation. Numerous terrestrial phenomena also fluctuate with solar activity. Sir William Herschel is credited with the first correlation of this nature, sunspots and the price of corn in England. Many correlations have been found — with or without physical significance — magnetic disturbances, radio reception, temperature, rainfall, growth of trees, height of water in the Great Lakes, financial depressions, sale of rabbit pelts in Canada, and the return of songbirds in the spring in France, including the early coo of the cuckoo. Northern and southern lights are here included, as their frequency and intensity follow solar activity very closely, including even minor fluctuations.

The last sunspot maximum, which was unusually flat and prolonged, was accompanied by many extraordinary auroras from 1937 to 1941. (See the front cover.) This year, auroral displays have been generally on the increase as we approach another spot maximum. The most spectacular northern displays are more frequent in Canada than in the northern part of the United States, and are rarely seen in lower latitudes. Auroras are more numerous in March and September, when the earth is more directly opposite zones of the sunspots, and there is some evidence that they are more numerous before midnight than afterward.

The sun is a large magnetized sphere with its north magnetic pole near its north pole of rotation; the latter is turned toward the earth in September. The general field intensity is about 50 gausses. The earth is also a magnet with its pole at present on Sverdrup Island in northern Canada and a field intensity about 1/100 as great as the sun's. Sunspots, however, develop magnetic fields of much higher intensity, frequently 4,000 or 5,000 gausses, occasionally as high as 20,000 or more. Large cranes for moving scrap iron utilize magnets with intensities of several thousand gausses capable of lifting a ton or more; but the most powerful, however, rarely equal one third the force of the strongest sunspots. These intense fields are the ones associated with magnetic storms on the earth, which disturb the compass, telegraph instruments, radio reception, and have a part at least in the production of auroral displays.

A sunspot is a violent whirlwind in the solar atmosphere. As the gases rush upward to a region of lower pressure they expand and cool, forming the dark central umbra, which is often large enough to engulf hundreds of planets the size of the earth. The outward mo-



An impression of the auroral corona of July 26th, drawn by Edgar M. Paulton. Accounts of this display are given on page 11.

tion of the whirling gases at low altitudes decreases the pressure at the center, facilitating ionization — the release of electrons from atoms. These electrons and possibly other electrified particles carried around by the vortical motion constitute electric currents spiraling upward like a current following a coil of wire. At right angles to the electric current is produced a strong magnetic field. We might liken this action to that of an inverted dynamo.

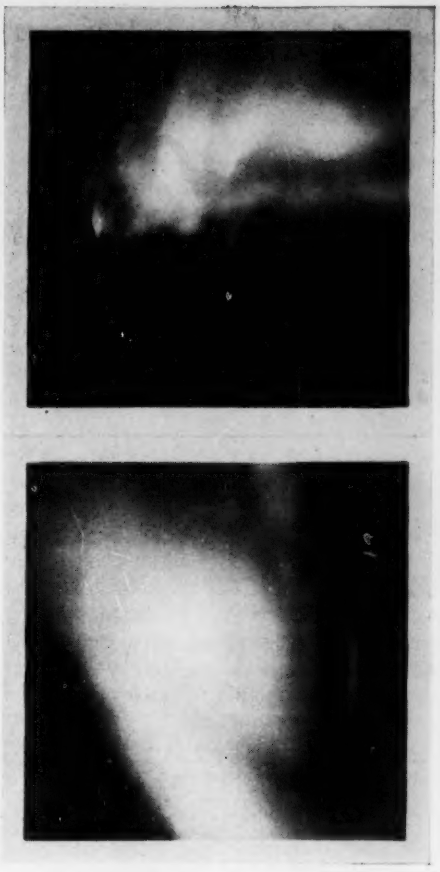
At the time of spot disturbances on the sun, the intensity of its radiation increases, sometimes as much as 10 per cent, with a larger relative increase in the ultraviolet. Also, the sun emits streams of electrified particles including swiftly moving electrons (unit negative charges somewhat resembling cathode rays), and it is quite probable that positively charged particles are also emitted.

The 25-hour delay after an active spot crosses the solar meridian, well marked in the case of magnetic storms on the earth, indicates a speed of about 1,000 miles a second, if the particles are emitted radially from the spot. Light travels from the sun to the earth in about 8 1/3 minutes, so the 25-hour delay seems to eliminate light rays as the chief factor in electromagnetic disturbances which are associated with aurorae.

At the McMath-Hulbert Observatory a motion picture was made showing that the head of a prominence was actually ejected from the sun. At a height of a million kilometers, it was ascending with the enormous velocity of 728 kilometers a second, which exceeds the sun's velocity of escape. The velocity had been increased by several sudden accelerations, another of which would have given it a speed greater than 1,000 miles per second.

Stoermer holds that cathode rays (electrons) are shot out from the sun, and probably positive rays also. Lindemann suggests that expelled hydrogen atoms are ionized at the extremely low pressure far from the sun, producing both protons and electrons. Swann proposes in connection with cosmic radiation in the earth's atmosphere that singly charged helium atoms come from the outside. He also maintains that the growth of a magnetic field in a rapidly developing sunspot region "could give to a charged particle of electronic mass an energy comparable to 10 billion volts."

Recalling that the earth is a magnetized sphere, its magnetic field acts as a lens on the parallel alpha and beta rays coming from the sun. So, even before these rays enter our atmosphere, they are bent toward a converging point and are drawn in along the earth's lines of magnetic force. The auroral streamers are along these trajectories, and, with the aid of perspective, converge in a whorl of light, the auroral corona, just south of the zenith. The lower ends of the



On September 26, 1940, this aurora was observed in Canada in the James Bay region. The lower picture is of the aurora in the zenith. Photo by the editors.

streamers are about 60 miles high or less. In higher latitudes, occasional streamers have been observed at altitudes of 500 or 600 miles. Electrons with energies of 100 million volts would hit the earth at a maximum distance of 17 degrees from the magnetic pole; with two billion volts, at a distance of 40 degrees.

The maximum frequency of the aurora borealis is at about 60° north latitude in North America and about 70° in Europe. It is interesting to note that the zone of maximum auroral frequency is centered not at the earth's magnetic pole but at a point where the needle is vertical, neglecting minor irregularities.

The luminous arc in the north in the direction of the earth's magnetic meridian is attributed to a built-up positive field more-or-less static. The flashing luminosity of the aurora is also an atmospheric phenomenon. Perhaps an analogy will be helpful. An electric spark will not jump across the gap until there are sufficient electrons or ions in the intervening space. The chain lightning from electrified clouds will not discharge to the earth until a path in the atmosphere, usually sinuous, is sufficiently ionized to make it conductive. Ball lightning, beaded lightning, rocket lightning, and sheet lightning are somewhat similar.

Let us add the expression, auroral lightning, to call attention to the important role ionization of the upper atmosphere plays in this luminosity. It seems quite probable that the increased intensity of solar radiation at the time of sunspot activity, especially that of extremely short wave lengths, facilitates the process of the ionization of atoms. This is quite similar to the well-known photoelectric effect — a spark that will not discharge under given conditions including a constant voltage will jump

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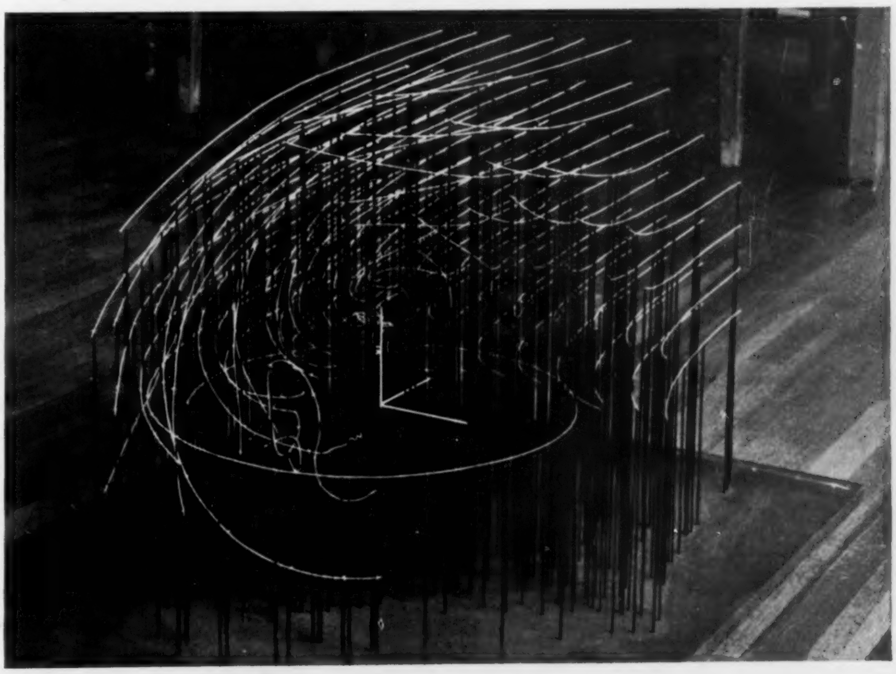


Wire model showing paths of electrified particles from the sun which cause the aurora, made by Carl Stoermer, at the Institute for Theoretical Astrophysics, Oslo, Norway. Photo by Clyde Fisher.

NEWS NOTES

By Dorrit Hoffleit

LUNAR AURORAS

Professor Mohd. A. R. Khan, of Hyderabad, India, has offered a suggestion (*Popular Astronomy* for June) for a decisive test on whether or not the moon has any atmosphere. "*If* there be any appreciable atmosphere on the moon, on account of its very tenuity it would give rise to auroral phenomena over that portion of the lunar surface that is lighted up by earthshine." Of course, he grants it would be asking too much actually to observe auroral streamers and other such displays. He suggests, however, that a study of the spectrum of earthshine on the moon might reveal the presence of the stronger of the forbidden lines of oxygen and nitrogen characteristic of auroras. To avoid confusion between lunar and terrestrial auroral light, simultaneous spectra of neighboring regions of the sky should also be obtained.

Professor Joseph Kaplan, physicist at the University of California at Los Angeles, who is a world authority on auroral spectra, supports and enlarges upon Professor Khan's suggestion. He adds that direct photographs made with infrared-sensitive plates and filters would record the auroral band at 15,000 angstroms, due to ionized nitrogen. Variations in such photographs should reveal the aurora's presence; they would require shorter exposure times and would be easier to obtain than the corresponding spectra.

GERMAN PUBLICATIONS

Reports are beginning to appear on the productive astronomical activities during the war years in Germany and occupied countries as well as on the destruction of observatories and equipment. In a recent issue of *Popular Astronomy,* Professor Gerard P. Kuiper, of Yerkes Observatory, gives a detailed account of his findings during a tour of German observatories from April to September, 1945. All astronomers will want to consult the bibliography he gives to learn of contributions in their respective fields, although Dr. Kuiper's bibliography includes some material already circulated by the Committee for the Distribution of Astronomical Literature.

Solar research was the most conspicuous branch of study, partly because of its application to the forecasting of ionospheric conditions. The Fraunhofer Institute was organized for such purposes and was to serve as a clearinghouse for solar data obtained at other stations. Four Alpine observatories were erected for the study of the corona. Plans had been made to use a V-2 rocket for pure research, including the measurement of sunlight in the far ultraviolet at high altitudes. This equipment was ready in July, 1944, but then the scientists did not succeed in getting their promised V-2 rocket. Similar experiments are now being attempted in this country.

AFTER SIX YEARS

Recoating aluminized mirrors is not necessary as often as resilvering used to be. The mirrors of the McDonald Observatory 82-inch had originally been aluminized by Dr. R. C. Williams, of the Michigan Observatory, in 1936. Last November, Dr. Williams visited McDonald as a consultant to advise on the aluminizing technique with the large aluminizing chamber completed by Dr. W. A. Hiltner. The secondary mirrors were all recoated. The large mirror, however, after cleaning, proved to be in such excellent condition that realuminizing can be postponed for at least another year.

PERPETUALLY OBSERVABLE COMETS

Comet Oterma has been observed within a month of being at aphelion, the point in its orbit most distant from the sun. It was located by Dr. G. Van Biesbroeck, of Yerkes Observatory, with the 82-inch McDonald reflector. This comet was originally discovered by a Finnish woman astronomer just three years ago. It now shares with Comet Schwassmann-Wachmann, discovered in 1925, the distinction of being visible from the earth through its entire course around the sun. Only the largest telescopes can pick up these comets at their greatest distances.

ECLIPSE EXPEDITION

From *Star Dust,* publication of the National Capital Astronomers, we learn that Leo Scott, president of that society, has been assigned to assist Dr. Irvine C. Gardner, of the National Bureau of Standards, with the corona cameras at the solar eclipse in Brazil next May.

The National Geographic Society-Army Air Forces eclipse expedition will be organized and financed largely by the National Geographic Society. The Air Corps will transport all personnel and equipment to Brazil. The Bureau of Standards will participate in the scientific expedition, as will Georgetown College Observatory. The U.S. Naval Observatory is not taking part.

Star Dust further reports that Father Paul J. McNally and Father Francis J. Heyden, of Georgetown, will endeavor to determine the times of the contacts by means of multiple-exposure photographs. They will use a 5-inch visual telescope with two 3-inch Ross lenses on the same mounting, one of 63 inches focal length, the other, 21 inches. While he is in the Southern Hemisphere, Father Heyden also hopes to photograph the southern Milky Way in red and blue light.

MORE TIME SERVICE

Science Service reports that requests for more frequent time signals than the standard four a day had been received at the Naval Observatory from astronomers, electric power companies, navigators, and industry. Hence, since August 1st, accurate time is now being radioed on short wave every second hour on the odd hour (EST) from the Navy's station at Annapolis.

ANOTHER NOVA REPEATS

Harvard Announcement Card 760 states that in a letter received from Kurt Himpel, of Heidelberg, Germany, a second rise to maximum of Nova Sagittae 1913 is reported. On the night of June 28th, Mr. Himpel observed a rapid increase of 2.6 magnitudes. Heidelberg observers noted a maximum magnitude of 8.0, after which the nova immediately began a steady decline to magnitude 10.4 (visual) on July 25th.

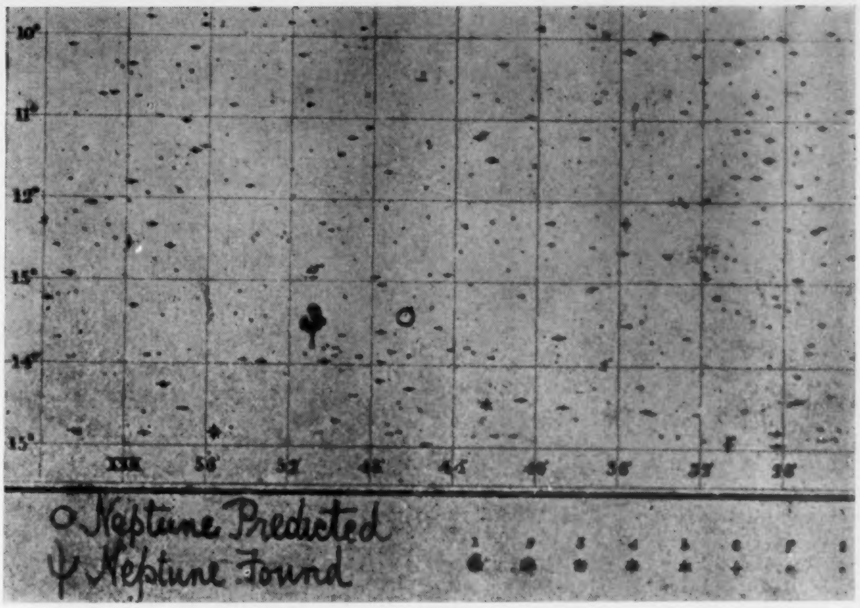
This rise to maximum has been confirmed by Mrs. Margaret W. Mayall by examination of Harvard patrol plates. The nova was not visible on a plate of June 27th, but was magnitude 8.9 (photographic) on June 28th, 7.8 on the 29th, and 8.2 on July 2nd. The latest photographic observation was magnitude 11.8 on July 27th.

S. R. M. TO MEET

Meteor Crater, Ariz., and the Arizona State College at Flagstaff will be the sites for the ninth meeting of the Society for Research on Meteorites, September 9th and 10th. Any person interested in meteoritics is invited to attend the sessions, which begin on Monday, September 9th, 9:00 a.m., at Flagstaff. The Tuesday sessions will be at the crater.

A TALK ON ROCKETS

Dr. J. A. Hynek will speak on "Rockets and Interplanetary Travel" at the guest nights of Perkins Observatory, Delaware, Ohio, Thursday and Friday, September 12th and 13th. The program begins at 8:00 p.m. As accommodations are limited to 140 persons each evening, application for guest cards should be made to Perkins Observatory, stating the night and the number of tickets desired. The lecture will be given whether the evening be clear or cloudy. If weather is unfavorable, a complete demonstration of the large telescope will be substituted for observing of the sky.



A corner of the Berlin map which was used by Galle and D'Arrest in searching for Neptune on September 23, 1846. Illustration, courtesy N. A. Mackenzie.

A CENTENNIAL
Discovery of Neptune

BY LEO MATTERSDORF

Amateur Astronomers Association, New York

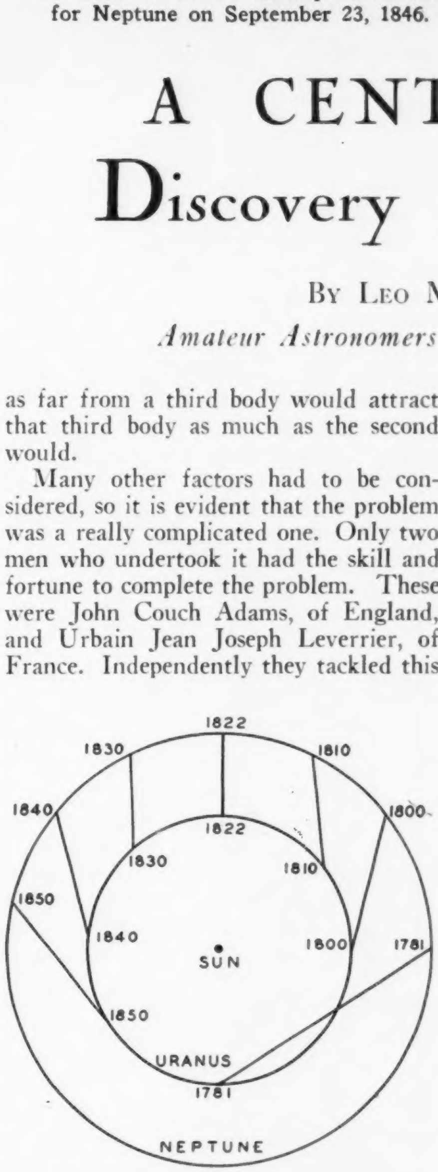
THIS IS THE STORY of a great triumph of mathematics, the story of the perseverance of two great minds until they finally had arrived at the solution of a mighty puzzle of nature.

Besides the earth, which they did not suspect of being a planet, the ancients knew but five of those wanderers of the sky — the ones visible to the naked eye: Mercury, Venus, Mars, Jupiter, and Saturn. It was 172 years after Galileo used the telescope astronomically that man first knew another planet. In 1781, William Herschel, then an amateur astronomer, perceived an object which moved among the stars. He first thought it to be a comet, but later it was recognized as a new planet. He named it Georgium Sidus, after his sovereign, George III, but in time this planet came to be known as Uranus. It was soon discovered that Uranus had been seen before but that its planetary nature had not been recognized. In fact, the great English astronomer, Flamsteed, whose work was described in *Sky and Telescope* last month, had observed it about a century prior to its discovery.

There were, in all, 19 prediscovery observations of Uranus, so astronomers were able to compute an orbit for the new planet, and, under all the orthodox rules, the planet was to follow that orbit. But no matter how the computations were varied to allow for this and that, Uranus failed to keep to its predicted path. These errors were very small, it is true, but by 1844 the discrepancy had increased to two minutes of arc, or about 1/15 of the apparent diameter of the moon. Every allowance had been made in the orbit calculations for the pull of the known planets, and especially for the big ones, Saturn and Jupiter. It was generally believed that Newton's laws would hold well beyond the known limits of the solar system, although this was to be the first real test. If Uranus were behaving according to the law of gravitation, there should be no such deviation between its observed and predicted positions.

Because Uranus seemed to accelerate in its orbit between the time of its discovery in 1781 and 1822 and thereafter seemed to be retarded, it began to appear that in the depths of space was another body, an unseen member of the sun's family, which was pulling Uranus from its normal path. But the problem of ascertaining the position of such a hypothetical planet was a tremendous one for, among other things, it practically meant determining the mass and distance of the body just from its gravitational pull. According to Newton's universal law, every particle of matter in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. Thus, a body four times as massive as a second body but twice as far from a third body would attract that third body as much as the second would.

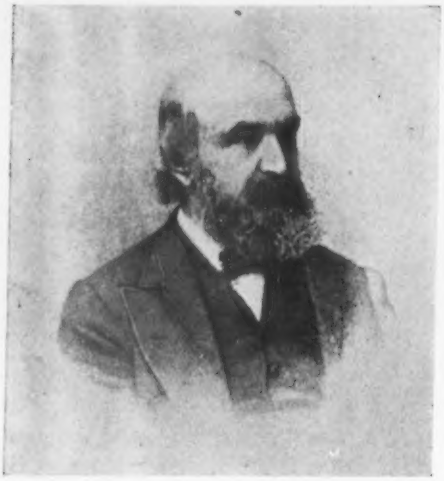
Many other factors had to be considered, so it is evident that the problem was a really complicated one. Only two men who undertook it had the skill and fortune to complete the problem. These were John Couch Adams, of England, and Urbain Jean Joseph Leverrier, of France. Independently they tackled this gigantic problem and history records that they both succeeded, although the calculations of one were pigeonholed and credit for a time went only to the other.



Prediscovery positions of Neptune show how it affected the speed of Uranus in its orbit from the time of that planet's discovery in 1781.

We must, however, give acknowledgment to the efforts of Alexis Bouvard, who in 1820 had drawn up a new orbit for Uranus based only on its positions since the discovery date; to the Reverend T. J. Hussey, who in 1834 attempted unsuccessfully to calculate the unknown planet's position; and to the famous German astronomer, F. W. Bessel, who in 1840 started on the problem but was deterred by illness until his death in the very year of Neptune's discovery.

In 1841, when Adams was 22 years old and a student in St. John's College, Cambridge, he resolved to attack the problem of the then unexplained irregularities in the motion of Uranus as soon as he received his degree. He obtained his first solution in 1843; other solutions came later, and by the fall of 1845 he was ready to put his figures to the test. Although Cambridge itself had the best instrument for the search (a refractor of 11½ inches aperture), Professor J. Challis of Cambridge sent Adams to see Sir George Airy, the Astronomer Royal, at Greenwich. Adams did go to Greenwich, but he did not see Airy. Once that gentleman was not in, then he was at supper and did not care to be



John Couch Adams (1819-1892).

disturbed, and so on. Adams left a note for Airy and this Airy acknowledged, but with a sidetracking question about the error in the radius vector of Uranus. Adams, however, was of too retiring a nature and instead of keeping after the Astronomer Royal, he let matters lag. Airy, himself, seems either not to have been sufficiently interested, or he may have believed the Greenwich telescopes to have been inadequate to verify Adams' work by observation. Even the fact that Dawes, an English astronomer, noted Adams' papers in Airy's possession did not help. Dawes asked Lassell, who had a large reflector and was later to discover Neptune's only satellite, to search for the planet, but Lassell was ill and the letter was accidentally burned.

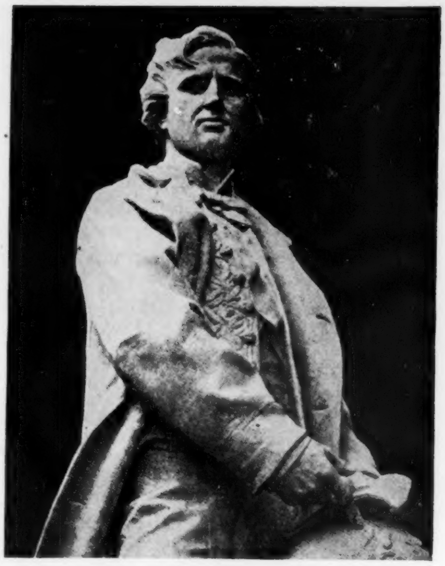
When Airy finally wrote Challis to look for Neptune, in July, 1846, Challis did so, but did not possess up-to-date charts of the region. We now know that he did see Neptune on two different occasions, August 4th and 12th, over a month before it was actually recognized and discovered, but he passed over it each time. Since his charts were inadequate, he used the old and laborious method of noting the positions of the stars in the field of his telescope and then, by looking again a few nights later, determining if any had moved. Challis evidently did not compare his observations with sufficient care to note that one of the stars he saw did move.

Leverrier, born in 1811, was a professional astronomer. In the summer of 1845, after Adams had practically finished his computations, Leverrier independently tackled the problem of finding the elusive body. Between the fall of 1845 and the summer of 1846 Leverrier submitted three papers to the French Academy. In these he showed that only a planet beyond Uranus could be responsible for its perturbations, and on August 31, 1846, in his third paper, he gave the elements of the planet's orbit and established the position it should then have in the sky.

Public interest was growing by leaps and bounds and on September 10, 1846, Sir John Herschel, in an address before the British Association, stated with reference to the yet undiscovered planet: "We see it as Columbus saw America from the shores of Spain. Its movements have been felt trembling along the far-reaching line of our analysis with a certainty hardly inferior to that of ocular demonstration." In less than two weeks the "ocular demonstration" was an established fact.

Knowing that the observatory at Berlin possessed a new chart of the region where the planet was expected to be found, Leverrier wrote to the chief assistant of the observatory, Johann Gottfried Galle (who lived until 1910), and asked him to look for the new planet at "a point on the ecliptic in the constellation of Aquarius, in longitude 326°." There, he said, Galle would find "within a degree of that place a new planet, looking like a star of about the ninth magnitude, and having a perceptible disk." Galle received the letter on September 23, 1846, and, unlike Airy, he lost no time in verifying the data sent to him.

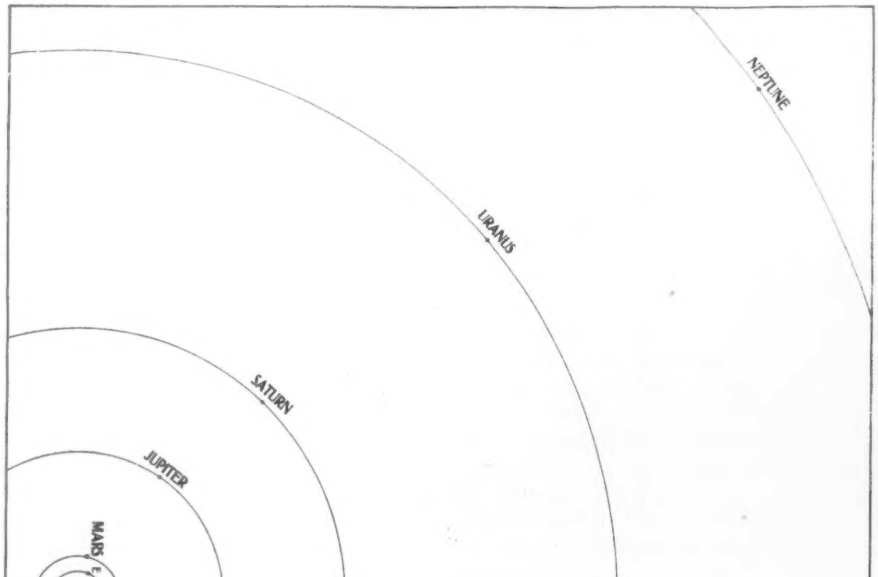
That night Galle, having received the consent of Johann Franz Encke, the director of the observatory, turned his telescope to the place in the heavens directed by Leverrier. (One version of the story is that the famous Encke did not think the matter more important than celebrating his birthday.) No object in the field of view presented a disk. An assistant, D'Arrest, who had offered to aid in the search, checked on one of the new charts the stars which Galle reported seeing through the telescope. Of nine objects in Galle's field of view, eight were stars and the ninth was Nep-



Urbain Jean Joseph Leverrier (1811-1877).

tune, within a degree of the spot computed by Leverrier. The object was kept under observation until after midnight, but it showed no detectable motion. The next night the strange object was seen to have moved from its position of the previous evening. The new planet had been found! It was perhaps the greatest achievement of mathematics as applied to astronomy, and it was a substantial verification of the theory of universal gravitation.

It is said that Leverrier, astronomer though he was, in the exactly 31 years which he lived after Neptune's discovery (he died September 23, 1877), never once looked at or saw the planet he had helped to find. As Adams' position was nearly as accurate as Leverrier's, these



This schematic diagram of the solar system, drawn to scale, shows the enormous relative size of Neptune's orbit.

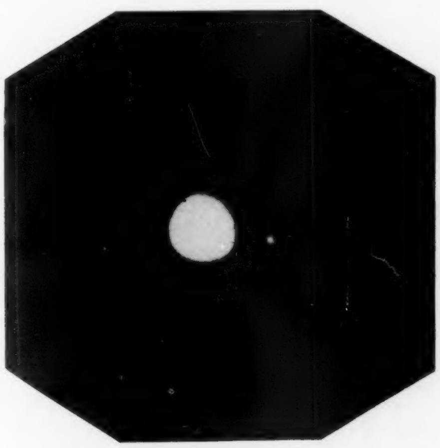
two mathematicians, a Frenchman and an Englishman, are today equally recognized as the discoverers of Neptune.

The orbit of Neptune is not that computed by either Adams or Leverrier, and many students have tried to show that it was a happy accident that the planet was found so close to the spot designated by these first predictions. Controversy on this matter is based on the fact that both computers used Bode's law of planetary distances from the sun. If you write a series of the following numbers, 0, 3, 6, 12, 24, 48, and so forth, and add 4 to each of these, you obtain the numbers: 4, 7, 10, 16, 28, 52, and so forth. If the earth's distance is taken as 10, the other numbers represent the distances of the planets from the sun, including the asteroids as one planet. This so-called law holds nearly for each planet until we get to Neptune, where it breaks down. Bode's law would place Neptune at about 39 instead of 30 astronomical units from the sun. Although Adams and Leverrier did use Bode's law, Russell, Dugan, and Stewart point out that while the available data and the methods of solution used were not sufficient to predict the planet's position far into the past or the future, they were good enough to give very close approximations to Neptune's distance and direction from the sun "during the time covered by the bulk of the observations." Incidentally, a recent theory by Weizsaecker concerning the origin of the solar system proposes a reason for Bode's law, hitherto considered just a strange coincidence.

Neptune revolves around the sun in a nearly circular orbit in a period of slightly less than 164.8 years, whereas Leverrier had predicted the period as 217 years. Its mean distance from the sun is about 2,796,600,000 miles. At this distance, sunlight is four hours old when it reaches the planet. On Neptune the sun's light has only 1/900 its brightness on the earth, but the planet appears to us as an object of magnitude 7.7, brighter than Leverrier had expected.

The diameter of Neptune is about 31,000 miles, so that it is a bit smaller than Uranus. Within a month after it was discovered, Lassell found its one satellite, named Triton. The motion of this moon is retrograde, that is, it revolves around the planet in a direction opposite to the direction of revolution around the sun. The rotation of Neptune itself, however, is direct, requiring about 16 hours. The plane of its equator is inclined about 29 degrees to the planet's orbit; the orbit of Triton is inclined about 20 degrees to the planet's equator.

Neptune, too, did not keep to its predicted orbit, and further unexplained differences developed in the positions of Uranus and some other planets. Although the differences were much smaller than Leverrier and Adams had to work with, Percival Lowell, in 1915, published the results of a detailed investigation of this new problem, and stated that he believed a trans-Neptunian planet existed at approximately 45 times the distance from the sun that the earth is. In 1930, 84 years after Neptune's discovery, Pluto was discovered, but it is still doubtful whether or not it is the planet Percival Lowell sought. However, it was discovered at the observatory he founded at Flagstaff, Ariz., and the initials of his name appear as the first two letters in Pluto and comprise its symbol.



Neptune and its satellite. The planet is overexposed considerably. Yerkes Observatory photograph.

ASTRONOMICAL ANECDOTES

QUIZ WINNERS AND THE HORIZON MOON

THE FOUR-QUESTION QUIZ given here in June brought many interesting replies. All four correct answers were given by Miss Kyle M. Petersen, St. Paul, Minn.; Miss Helen M. Stephansky, Jamaica Plain, Mass.; and Joseph Ashbrook, Cambridge, Mass.

Prizes were offered for three of the four answers, and C. W. Adams of Norfolk Mansions, London, England, Franklin W. Smith of Boston, Mass., Berge Tatian of New York City, and Robert Lee Stimmel of Lima, Ohio, qualify on this score. Ere this issue is distributed, all seven of these correspondents will have received the promised rewards.

Until this moment — it's Hiroshima Day, 1946 — I didn't realize that there were seven prize winners. The mystic number, 7, has been running through my mind, recently, as I realize that the seventh year of my doing of this column will soon be coming to an end. I might suggest to the editor that any one of the three four-answer folks of the first paragraph would be a reasonable choice as a successor.

I tossed in a very informal question about opinions about the apparently enlarged moon at the horizon and found, to my amazement, that many amateurs do not appreciate the fact that it is a complete illusion. I received several letters telling me that the earth's atmosphere is responsible, because it enlarges the moon. This is not true, of course. The earth's atmosphere refracts the light from an object (such as the upper or lower edge of the moon) in such a way as to "lift" it. The lower the body is in the sky, the more it is lifted; the lower edge of the moon is lifted more than the upper edge, so the moon appears flattened. The left-to-right (horizontal) dimension is not changed by the refraction of the atmosphere. Those who wrote to me incorrectly had better go back and read their text references on refraction a little more slowly.

Dr. Thomas T. Jones, of Durham, N. C., who almost made it, in the quiz, suggests that the correct explanation of the illusion is given on pages 101-102 of Fred L. Whipple's *Earth, Moon and Planets* (one of the Harvard Books on Astronomy). He is right, although this is, as Dr. Whipple explains, only half the answer.

When the moon is rising or setting, it is a little less than 4,000 miles *farther* from us than when it stands highest in the sky. It then *should* appear smaller when it is close to the horizon, but it doesn't. However, it actually does have a smaller apparent diameter or angular diameter, as can be shown by instrumental measurement. But the eye defies the result of measurement, and insists that the rising or setting moon is larger than the culminating moon.

Dr. Edwin G. Boring, Harvard University psychologist, has recently re-examined this problem, coming to the conclusion that it is a psycho-physiological phenomenon. The human eye has a strange quirk that produces the apparent enlargement of the horizon moon. Objects that are directly in front of the eyes appear larger than objects of the same size that are located so that the eyes must be lifted to see them.

In other words, an observer lying on a slanted board, so he can look directly at a high moon, will see it as large as the horizon moon, viewed when the observer stands on his feet. This has been tested by actual experiment and has been found to be true. The human eye-and-brain combination is responsible.

Look at a horizon moon and note that it is enlarged. It appears tremendous. Now raise the hand and frame the moon between thumb and forefinger; the moon shrinks at once. Another way to do it is to look at the horizon moon in a mirror.

(*Continued on page 18*)

Amateur Astronomers

THIS MONTH'S MEETINGS

Chicago: The Burnham Astronomical Society will hold its regular meeting in the Chicago Academy of Sciences Auditorium at 8:00 p.m. on Tuesday, September 10th. Dr. Oliver J. Lee, director of Dearborn Observatory, will present the well-known astronomical motion picture, "Looking Through Great Telescopes."

Cincinnati: At the meeting of the Cincinnati Astronomical Association on Friday, September 13th, Dr. Sidney W. McCuskey, of the Warner and Swasey Observatory, Cleveland, will lecture on "The Milky Way." The meeting is held at the Cincinnati Observatory, at 8:00 p.m.

Detroit: On Sunday, September 15th, the Detroit Astronomical Society will meet at Wayne University, at 3:00 p.m. William Schultz, Jr., of the Cranbrook Institute of Science, will discuss "Atomic Energy and the Atom Bomb."

Geneva, Ill.: At the September 15th meeting of the Fox Valley Astronomical Society an astronomical quiz will be conducted, and there will be observations of the Milky Way. The time and place of this meeting are to be announced.

Indianapolis: "Clusters and Nebulae" will be discussed by Dr. W. A. Cogshall at the September 1st meeting of the Indiana Astronomical Society, which meets at Odeon Hall at 2:15 p.m.

Kalamazoo: On September 14th, at the regular meeting of the Kalamazoo Amateur Astronomy Association, William Persons will speak on "The Tides." The meeting is at the home of Dr. H. R. Cobb, 3319 Knox Avenue.

Cranbrook Exhibit Awards

A final tabulation of the prize winners in the exhibit at the Fourth National Convention of Amateur Astronomers at Cranbrook, July 5-7, 1946, has been announced.

Class 1. Amateur-made telescopes: *First prize,* Joseph P. Gillis, Martin's Ferry, Ohio. *Second prize,* Don C. Jardine, Chicago, Ill.

Class 2. Photographs of amateur-made telescopes: *First prize,* Dr. Henry E. Paul, Norwich, N. Y. *Second prize,* L. Strum, St. Petersburg, Fla.

Class 3. No entry; no prize.

Class 4. Telescope parts and accessories, amateur-made: *First prize,* G. F. Spracklin, Windsor, Ontario. *Second prize,* Clayton F. Howe, Decatur, Mich.

Class 5. Astronomical photographs taken with amateur telescopes. *First prize,* Dr. Henry E. Paul, Norwich, N. Y. *Second prize,* L. Strum, St. Petersburg, Fla.

Class 6. Miscellaneous: *First prize,* Agnes Hastings, Philadelphia, Pa. *Second prize,* Dan Hazeltyne, Detroit, Mich.

Navigation Journal

The journal of the Institute of Navigation is now published quarterly, in March, June, September, and December of each year. The latest issue of *Navigation* is for June, 1946, Volume 1, Number 2. It contains 20 pages within its covers, in two-column format with ample illustrations and diagrams.

The contents of this new popular journal reflect the wide range of subjects comprised by current navigation practice and theory. It is notable that two of the authors in the June issue are astronomers: Dr. Samuel Herrick, of the department of astronomy at U.C.L.A., writes on "Instrumental Solutions in Celestial Navigation," and Dr. Robert S. Richardson, of Mount Wilson Observatory, discusses Captain Thomas Hubbard Sumner, this article being a reprint from the *Publications* of the Astronomical Society of the Pacific. The other articles in this issue are entitled: "Aerologation," "Interpretation of the Celestial Line of Position," and "Accuracy of Position Finding Using Three or Four Lines of Position."

Membership in the Institute of Navigation is open to all persons interested in navigation or related arts and sciences. The annual dues are $5.00, and include a subscription to *Navigation.* Principal headquarters of the Institute are at the University of California, Los Angeles 24, Calif.

Kalamazoo Activities

The Kalamazoo Amateur Astronomy Association was organized in 1936 by a small group of men and women interested in astronomy. We now have 52 members, and meet in private homes nine months of the year, one meeting per month. About 10 of our members have their own telescopes and more are being built. One member has made six instruments, from 3-inch up to 12½-inch. We have speakers from neighboring colleges, and our own members take part in our programs.

Our vice-president, Clayton F. Howe, won second prize on his turret eyepiece at the Cranbrook convention. We are looking forward to being a member of the Amateur Astronomers League.

Mrs. George Negrenski, secretary
2218 Amherst Ave.
Kalamazoo, Mich.

Central High School Planetarium

The first projection planetarium for high-school use in this country will be housed in the new building of the Central High School, at Ogontz and Olney Avenues in Philadelphia. It is a gift of Mrs. Franklin Spencer Edmonds, in honor of her late husband, a lawyer and state senator. The projector will be housed in a dome 21 feet in diameter in a specially designed room in the basement of the school.

Central High School, which has its own observatory, has pioneered in teaching astronomy for over 100 years. Charles T. Yerkes, donor of the Yerkes Observatory, was a graduate of this school, where numerous astronomers have started their careers.

During a trip to Canada last year, the president of Central High School was shown the planetarium in the High School of Montreal. A similar instrument will be used in Philadelphia. It is manufactured by the Peerless Planetarium Co., Toronto, shows stars down to and including the 4th magnitude, the sun, the moon, and the naked-eye planets. By manual operation, the diurnal motion of the heavens, the effect of a change in latitude, and precession can be demonstrated.

A very realistic and effective orrery is included in the new installation. The head of the department of mathematics and astronomy at Central High School is A. Clyde Schock.

A Pink Moon!

Dr. James C. Bartlett, of Baltimore, Md., writes that on July 11th, while observing with a 3-inch refractor, he noticed that the moon was not of normal color. The whole surface appeared to be suffused by a delicate, pinkish glow which was visible to the naked eye as well as through the telescope.

When Dr. Bartlett applied a blue filter to the eyepiece and then withdrew it, the pink color became quite marked. Seeing was poor, and a thin altostratus sheet was in the process of formation. As this thickened, a corona appeared which was also pink, a light salmon color. There were no other colors, and the pink was observed independently by Dr. Bartlett's wife.

The Baltimore amateur states further that although monochromatic coronas are well known, the lunar disk does not usually partake of the coronal color.

New Officers at Pittsburgh

The Amateur Astronomers Association of Pittsburgh has elected new officers for the year 1946-1947. They are W. A. MacCalla, president; Louis E. Bier, vice-president; James E. Brugh, secretary; Harry J. Collins, treasurer.

A Widespread Aurora

NAVAL OBSERVATORY astronomers noticed a large spot group just appearing on the edge of the sun on Friday, July 19th. The group increased in area as it moved over the sun's disk. A week later it was nearly central, and about two thirds as large as the gigantic February group, largest on record. It gave great promise of producing a good display of the northern lights and, fortunately, the night of July 26-27th was clear over most of the eastern United States. Reports from a score of amateurs in widely separated localities testify to the brilliance of that night's aurora. The following are excerpts from these reports.

The aurora at 2:00 a.m. CST July 27th, as photographed at Fort Wayne, Ind., by Bob Smith, of the Neuman Studio. Exposure was two minutes at f/5.6 on Tri-X film; direction slightly north of west. Photograph transmitted by R. W. Noland.

About 8:45 p.m. [presumably CST] a greenish-blue streak was noticed in the northeast, reaching 45° above the horizon. Immediately after this the drapes spread across the northern horizon to the northwest and up to 60° high in most places. In the higher portions the colors were red and orange, contrasted with the greens and blues of the horizon.

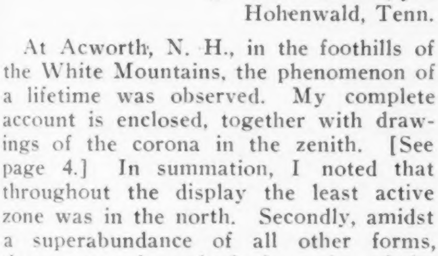
At 9:00, the display was at its height. A strong background buzz was noticed in the radio reception at 650 kilocycles, but not enough to seriously impair the listening. At 9:15 the main display was over, but the horizon continued to glow.

C. W. NESTOR, JR.
Hohenwald, Tenn.

At Acworth, N. H., in the foothills of the White Mountains, the phenomenon of a lifetime was observed. My complete account is enclosed, together with drawings of the corona in the zenith. [See page 4.] In summation, I noted that throughout the display the least active zone was in the north. Secondly, amidst a superabundance of all other forms, there was only a single formation of the draperies and this was not clearly defined. Finally, the quick tempo of the entire procedure left the observer with a sense of bewilderment. But I do not expect to see a bigger or a better display. This one I watched from after sunset to 3:00 a.m. EDT.

EDGAR M. PAULTON
New York City

Friday, July 26th, appeared to be a good night for stellar observation, but as night came on there was a luminous band across the sky almost exactly following the zodiac, and we believed it to be the zodiacal light. Soon, however, to our dismay, we found it to be the aurora borealis. When bright yellow-green streamers began waving in the south over Antares, we got together our equipment and started down the hill from which we were planning to observe. As we walked home we took more interest in these northern lights.



An enlargement of the group of sunspots when it was near the center of the disk of the sun on July 26th. U. S. Naval Observatory photo.

Red streamers began to form north of Jupiter; then they moved northward about one degree every 15 seconds. Later, as if someone had thrown a switch, the whole sky lit up with auroral light, and this kept up until a little after midnight.

BRADFORD A. SMITH
Winchester, Mass.

Last night we witnessed one of the most brilliant auroras I have ever seen, surpassed, perhaps, only by the one seen in New York in September, 1941. That one was more colorful.

At first the southern horizon was most brilliant, but with rays shooting up from the north and west. Then an arch spanned the heavens from west to east through the zenith. At 10:30 p.m., the entire heavens became aglow, and the light surpassed that of the full moon. Green was the predominant color, although a little red was visible in the west. Overhead a figure somewhat akin to the old NRA eagle took shape at the top of an arch with pronounced shimmering. All in all it was a sight I won't forget soon.

LEO MATTERSDORF
Chesterfield, N. H.

On the morning of July 25th, the prominent sunspot was observed by me clearly visible without telescopic aid. That night there was the characteristic faint auroral glow in the north extending not more than 10° above the horizon at 10:30 p.m. EDT. At 4:00 a.m. July 26th, the auroral glow had disappeared from a very clear sky.

At 10:00 p.m. on the evening of July 26th, there was no sign of lights in the north, but to the south a distinct auroral glow was seen. The southern limit of this glow remained relatively fixed, passing close to Epsilon Scorpii and Epsilon Sagittarii. By 10:30, the illuminated area had spread north of the zenith and a corona was formed near Mu in Hercules. At 10:40, red colors began to come and go near the prime vertical; by 11:00 the brightness of the display reached a maximum, with 4th-magnitude stars in Corona Borealis just visible. By midnight the aurora had lost much of its form and brilliance but was still widespread.

Edwin Root reported to me that the lights were again very bright with the corona conspicuous at 2:30 a.m., July 27th. That morning at four o'clock I made my final observation and found the aurora had reverted to an exclusively southern sky show with a tendency toward a flaming aurora. No displays were visible on subsequent nights.

PAUL W. STEVENS
Rochester, N. Y.

The aurora borealis a few nights ago was very plain from here. At 9:00 two pyramid shafts of white light, one just to the right of the North Star, could be seen to the zenith; there were several streaks but very little color. The shaft to the west was through the bowl of the Big Dipper. Two brilliant streaks through the center of it lasted for probably 30 seconds.

At 9:15 p.m. it was all gone. Such displays are very unusual this far south.

B. L. HARRELL
Gadsden, Ala.

I am a 14-year-old amateur astronomer. On the 24th of July I found without optical aid a large sunspot group and have been waiting for the aurora which I thought would appear.

Before darkness on July 26th, the sky had two bands across it from west to east south of the zenith. After dark they moved off to the south and faded out. Pul-

(Continued on page 21)

GREAT DI

By Robert R. Col

IN ASTRONOMY, as in every other science, certain names bring to mind various interesting and important mileposts along the highway of learning. Thus when we hear of Copernicus, Tycho Brahe, Galileo, or Kepler, we naturally visualize those pioneer days that witnessed the dawn of modern scientific astronomy, when man was beginning to comprehend something of the true picture of the universe and to learn about the architecture and mechanics of the solar system. These names belong to astronomy just as those of Columbus, Magellan, and Mercator belong to geography and the names of Darwin and Huxley are associated with biology.

In one sense it may be said that the era of astronomical discovery was launched with the first use of the telescope by Galileo during the early years of the 17th century. But we must not forget a number of remarkable achievements that antedated this era by many centuries. Among these are the contributions of the ancient Egyptians, the Chinese, the Chaldeans, and the Greeks. Their construction of a calendar based upon a knowledge of the recurrence of celestial phenomena, the discovery of the saros period, and their fairly accurate speculations regarding the general shape of the earth and the structure of the solar system indicate that many individual observers did some pretty clear thinking on these matters some 2,000 years before the time of Galileo and his telescope.

To this we must add the determination of the earth's circumference by the Greek astronomer, Eratosthenes, in 250 B. C., and the discovery of precession of the equinoxes by Hipparchus in 125 B. C. Both of these achievements were of the greatest importance in the development of the science. Before the time of Galileo, astronomers were greatly restricted in their work due to the absence of precise instruments to carry on their observations. The best equipment available was that of Tycho Brahe, who was born just four centuries ago, and the instruments in his great observatory were the marvel of the age.

Most famous of Tycho's discoveries was his observation of the great nova in Cassiopeia in 1572. His proof that this object was actually a star, far more distant than the planets, is a noteworthy example of scientific reasoning. Another contribution that added materially to man's knowledge of the heavens was Tycho's discovery that comets are much more distant than the moon and that they really belong in the realm of the planets. And quite as important as anything else was the aid and encouragement that he gave to Kepler, who worked with Tycho and later based his famous computations largely on the observational notes that Tycho had made.

With Galileo's first use of the telescope, man began extending his cosmic horizons and discovering thousands of objects that had previously been hidden in the depths of space. Even the first observational discoveries that Galileo made, including the four large satellites of Jupiter, the phases of Venus, the presence of individual stars in the Milky Way, and the determination of the sun's rotation by observation of sunspots, provided a tremendous impetus to the study of astronomy. It was as if man were viewing the heavens through a magic window — what he saw served at once to destroy many preconceived notions and to open up entire new fields of thought. It was Galileo's discovery of the satellites of Jupiter and the phases of Venus that provided strong observational evidence in support of the famous Copernican theory.

The earliest astronomical photographs, made with wet plates by Bond at Harvard in 1857. Upper left, Mizar; upper right, Saturn; bottom, the moon and a star.

It is impossible in one brief article to mention, even in outline, the many extraordinary discoveries that have been made in the time of over three and a quarter centuries since Galileo's day. And any attempt to single out the half dozen or so of greatest importance would be a matter of individual opinion.

In regard to our own corner of space, the solar system, the names of Kepler and Newton rank with that of Copernicus. It was Kepler who determined the elliptical form of the planetary orbits and whose famous laws of planetary motion provided an important lead for the outstanding achievements of Newton. In the great popular work, *Splendour of the Heavens,* Tycho and Kepler are described as "having provided the connecting link between the theorics of Copernicus and the discoveries of Newton." Then there is Halley, who worked with Newton and predicted the return of the comet of 1682, now named after him.

The rings of Saturn were described by Huygens in 1655, and by the end of the 17th century five of its nine satellites had been discovered. But while Galileo had discovered the four largest satellites of Jupiter in 1610, it was not until as recently as 1892 that Barnard discovered the fifth, and the other six have all been found since 1904.

While obviously passing over a long and important period during which many notable strides were made, we might next mention the discovery of Uranus by William Herschel in 1781. This was the first of the planets to be discovered, since all those visible to the naked eye had been known from the dawn of history. Uranus was found by Herschel quite accidentally and at first was believed to be a comet. Several months passed before it was definitely identified as a planet.

The discovery of Neptune 100 years ago this month is recounted in a separate article in this issue of *Sky and Telescope.* The event has been described as "the greatest triumph of mathematical astronomy since the days of Newton." And, of course, the finding of Pluto at Lowell Observatory in 1930 stands as another important achievement.

Practically all our references thus far have been to discoveries pertaining to the solar system. Due in large part to the impetus received through develop-

DISCOVERIES

Hayden Planetarium

ments in the telescope, real strides began to be made in studies of the stellar system. By the middle of the 18th century, telescopes had been greatly improved over the crude form that was used by Galileo in his first observations. The reflecting telescope had been developed, and several modifications of this type were being used. The first great contributions to a wider knowledge of the universe may be said to have been made by Sir William Herschel, who made extensive observations of stars and nebulae and suggested the famous "grindstone" theory in his attempt to explain the architecture of the Milky Way galaxy. He also contributed much in the study of double stars, and by painstaking observations of stellar motions discovered the motion of the sun toward the constellation Hercules. In 1822, Sir William died. His son, John Herschel, carried on the brilliant work that his father had begun. In 1834, he established an observatory near Cape Town, South Africa, where he spent four years studying the southern heavens. He also did considerable work on double stars, clusters, and nebulae.

In 1838, Bessel made one of the first precise determinations of the distance to a star when he measured the parallactic displacement of 61 Cygni. And in 1844 this same brilliant astronomer predicted the existence of the companion of Sirius. This was some 18 years before the telescopic discovery of the star by Alvan G. Clark in 1862. With these achievements it may be said that the era of precision astronomy was well started. Man's field of exploration had extended far beyond the solar system although many interesting discoveries were yet to be made nearer home.

In the years that Bessel was making his greatest contributions, the infant science of photography had its beginning. And it was only a relatively short time before the sensitized photographic plate was coupled with the telescope to record the images of celestial objects. Then, in 1859, the spectroscope was added to the telescope and astronomers began identifying the chemical elements of the sun's atmosphere. These two adjuncts, launching modern astrophysics, gave the astronomer just the tools he needed.

In 1863, Secchi's classification of stellar spectra was published, and it became obvious that the stars were not made of the same stuff that is found on the earth and in the sun. During the solar eclipse of 1868, a new element, later named helium, was discovered in the atmosphere of the sun. This gas was not identified on the earth until 27 years later. In 1888, Vogel combined spectroscopy and photography to measure the radial velocities of certain stars by the Doppler shift of the lines in their spectra.

The great star clouds of the Milky Way in the Sagittarius region have furnished ample material for students of the heavens.

During the years that followed, important catalogues of stellar spectra were made, the magnitudes of thousands of stars were accurately measured, and much work was done on binary star systems. By the early years of the present century, the science of astronomy developed so that many research workers were devoting their entire lives to highly specialized studies. Stellar temperatures and diameters had been calculated and, through a study of double stars, their masses determined. Theoretical work had even told us something of the composition below the surfaces of stars, and recent nuclear research has given a logical answer to the question of how their tremendous energy is produced. In these fields of thought, physicist, chemist, and astronomer must work together.

In 1912, the interesting relation between the periods and magnitudes of Cepheid variables in the Small Magellanic Cloud provided a new yardstick for measuring the depths of space to the galaxies beyond the Milky Way. Research by Hubble and Shapley has given us a clearer picture of the distribution of these distant systems and of their relation to one another.

In one sense it is true that the world of the astronomer is far removed from that of the average man or woman. But the stars are not the personal possession of the few whose business it is to measure them and theorize upon them. They are the common property of all with eyes to see and with sufficient interest and curiosity to wonder. An acquaintance with the stars and planets that populate the heavens and a knowledge of the development of man's progress in exploring the sky will add to one's interest in and appreciation of the celestial picture.

BOOKS AND THE SKY

SUN, MOON AND STARS

William T. Skilling and Robert S. Richardson. Whittlesey House, McGraw-Hill Book Company, Inc., New York, 1946. 274 pages. $2.50.

I HAVE READ every word of this book, and find it most interesting. I am sure that studious beginners in astronomy will be fascinated by the topics discussed and by the manner of presentation.

The book is divided into five parts: The Moon, The Sun, The Planets, The Stars, Astronomers and Observatories. Several interesting topics, not commonly mentioned in similar works, are discussed: An Imaginary Visit to the Moon, Radar Contact with the Moon, Sun and Atomic Bomb Compared, Seasons on Other Planets, and Stargazing at Large Observatories.

The authors supply an abundance of easily understood analogies. The shadow method of determining the heights of lunar mountains is illustrated by the shadows of people on a street as seen from the top of a high building. The volume of an atom before and after being stripped of orbital electrons is compared with the volume of an empty wooden box before and after collapse. The appearance of the Milky Way as compared with the rest of the sky is illustrated by the greenness of a pane of window glass when looked through edgewise and the clearness when looked through flatwise. The light-year is so clearly defined as to leave no occasion for the statement once found in a University of Oregon examination paper, "A light-year is much longer than an ordinary year."

A most convenient feature is the pronunciation of unfamiliar words on the pages where they are first used. On many pages, practically duplicate pictures are placed side by side so they may be viewed through a stereoscope and the sensation of depth obtained. The index is very complete. There seem to be almost no typographical errors, although on page 219 the word "seconds" should follow "1.52."

Very few statements seem to be incorrect. The last paragraph of page 34 reads, "At the North Pole, where neither the sun nor the moon sets at all in the summer, the moon is full even at midnight, and both it and the sun are fairly high in the sky, in opposite directions." As the full moon of summer is always far below the celestial equator, the circle which at the North Pole coincides with the horizon, the statement quoted above is obviously incorrect.

On this same page, the authors say, "in the winter, as you can see by watching, the moon lacks two or three days of being full when it rises at sunset; and in the summer at sunset the full moon is already some distance above the horizon." The **Nautical Almanac** for 1946 shows that the full moon of December 8th will rise at 2:40 p.m. and the sun will set at 2:56 p.m., at latitude 60° north on the meridian of Greenwich. At this same place, the full moon of June 14th rose at 9:24 p.m., and the sun set at practically the same time. At latitude 30° north, these differences are seven and three minutes, respectively.

There seem to be a few minor errors and omissions, but what book is free of slight errors? Meteorites might be mentioned as a major danger to space ships (page 21). Refraction will sometimes permit both the sun and the eclipsed moon to be seen at the same time (page 39). On page 51, the angular separation of the Pointers of the Big Dipper is given as about four degrees, whereas these stars differ in declination by five degrees and 22 minutes. As they are almost on the same hour circle, "over five degrees" seems a better approximation. On page 218, Fomalhaut is placed in the constellation of Grus, instead of in Piscis Austrinus.

Sun, Moon and Stars is a splendid book. It is "slanted" for the more mature teen-agers. No book that "enters into the arcana" of astronomy can be assimilated by a beginner without some mental effort.

J. HUGH PRUETT
Extension Division, Univ. of Oregon

MEN, MIRRORS, AND STARS

G. Edward Pendray. Harper and Brothers, New York, 1946. Third edition, revised. 335 pages. $3.00.

THIS WELL-KNOWN CLASSIC, in which Mr. Pendray first told in 1935 the fascinating story about the development of modern astronomical instruments

and the men who made them, has been revised for the second time after a lapse of seven years.

Men, Mirrors, and Stars has been a "must" book for many years to all those interested in astronomy and its development. The author has an interesting and readable style and has done full justice to the romantic story of the men who have cast our vision into the uttermost depths of space. It speaks well for the author's perception and imagination that, even after a lapse of 11 years, it has not been found necessary to revise the last chapter, "Telescopes of the Future," in any particular.

In this reviewer's opinion, the revision leaves something to be desired. It is presumed that the reason for its preparation has been to bring the story of the 200-inch Mt. Palomar telescope up to date, but inasmuch as this instrument will be finished in little more than another year, it would seem more desirable to have waited until the complete story could be told. Except for the rewritten chapter on the 200-inch, owners of the first and second editions will not find sufficient new material to warrant their purchase of the third edition, although those who have never owned a copy will, of course, much prefer the latest printing.

It is unfortunate that many of the original references to illustrations have not been corrected, inasmuch as nine of the illustrations are new. This is especially annoying because the illustrations are collected into two groups instead of being distributed through the book so as to be somewhere near the pertinent subject matter.

The reviewer feels that the omission of the interesting chapter on amateur astronomers and their valuable contributions, to make way for material on the Schmidt camera and the coronagraph, detracts from the value of the book.

Perhaps more important is the fact that certain minor errors which were present in the original edition still persist. The sketches of telescopes in Figures 7 and 8 are still incorrectly drawn; on page 45 the description of spherical aberration is wrongly stated again; and on page 188 the spectral classification of stars is still referred to as illustrating stellar evolution, although in recent years this idea has been mostly discarded by astronomers. A distinct omission is the failure to mention resolving power in the discussion of magnifying power and light-gathering power; another is the lack of any reference to the Ross correction lenses which alone can make the large reflectors cover a useful field of view.

Men, Mirrors, and Stars remains the only book of its kind, and it deserves an honored place in the library of every reader of this magazine. It is doubtful if anyone else could have told this particular story as well as Mr. Pendray has.

EARLE B. BROWN

NEW BOOKS RECEIVED

SCIENCE AND THE PLANNED STATE, *John R. Baker*, 1945, *Macmillan*. 120 pages. $1.75.

The arguments presented in this book are definitely against state control of scientific research. The author is a lecturer in zoology at Oxford University.

GLEANINGS FOR A. T. M.s

A Method for Compensating Pendulum Clocks

Several years ago I decided to construct a device to compensate the pendulum of a clock for temperature. After studying various methods for doing this, I found that each was more-or-less complicated and involved quite an investigation of theory, so I set out to design my own method, which has proved rather satisfactory.

After the final adjustment was made, the clock kept time steadily. It varies about three seconds or less and part of this may be due to the striking mechanism. The clock does not have a second hand, so I have to do my checking by the striking of the clock itself. The short-wave radio time signal comes in somewhere between the first sound of the gong and the fourth sound, which is about the three seconds mentioned above. This never varies, although the clock is exposed to all of the elements except direct sunshine and rain.

Incidentally, I have a five-inch bronze bell mounted atop the clock supported by brass tubing. A striking device is so designed as to sound the gong on the hours, the regular strike on the half hours.

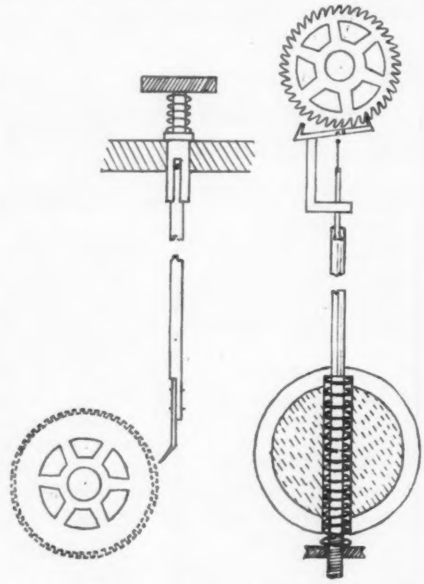
Fig. 1 is a device to keep the clock works in motion while winding the spring. A little pressure applied to the top of the knob will engage the ratchet in gear, giving it a continuous motion while the spring is being wound.

Now for the compensator, shown in Fig. 2. First, adjust the pendulum until the clock keeps reasonably good time, then measure the distance from the top of the adjusting nut to the supporting pin. Next, select a stiff steel compression spring that will slide comfortably over the pendulum rod. Turn or select a wooden form with the same diameter as the inside diameter of the compression spring. Cut a piece of soft iron wire the same length as the distance from the supporting pin to the adjusting nut. Wind this wire about the wooden form with the same pitch as the heavy spring. Then grind off the heavy spring to the same length.

The pendulum bob should be weighed accurately, as this weight must be reproduced later. Then drill and ream a hole, starting at the bottom of the pendulum bob. Make this hole a little larger than the outside diameter of the compression spring and just deep enough to allow the spring to protrude slightly from the bottom of the bob. Do not drill all the way through, but leave a shoulder for the bob to rest on the spring.

In drilling the hole, more material may be removed than the spring will replace, so weigh the pendulum bob and spring and add enough weight to make it equal the original weight of the bob. If there is room, the bob can be lowered to compensate for the loss in weight.

Insert the spring in the bob, making certain there are no sharp edges and that the spring makes a good loose fit, but not a "sloppy" fit. Note that the compression spring should support the pendulum bob without any compression. We have determined the spring's length by the



Left: Fig. 1. A device for holding clock works in motion, while winding. Right: Fig. 2. The compensation device designed by Mr. Witherspoon.

EDITED BY EARLE B. BROWN

means described above as exactly the same as that of the pendulum assembly.

Now replace the entire pendulum assembly with the adjusting nut in approximately the same place; fix the clock to a sturdy shelf or wall with screws, seeing that it is level (use a spirit level). Then use the winding key to adjust the escapement to the correct speed. This may require several days. I know of no way to adjust the rate of escapement except by trial and error — this is tedious, but can be done.

EARL C. WITHERSPOON
21 Warren Street, Sumter, S. C.

THE EDITORS NOTE

(*Continued from page 2*)

off by R. W. P. This year most of the speakers were professionals who described their various wartime experiences.

In answer to the question uppermost in everyone's mind, Dr. Porter stated that it is expected the 200-inch telescope will be in operation within a year. The mirror is almost completed — now parabolic within one wave length — and very likely to be finished next spring. The mounting is essentially complete, but a number of small mechanical jobs may require several additional months before the big eye can start plumbing the depths of space. Frequently the mounting and the dome are given a workout. Meanwhile, on Palomar mountain, a battery of Schmidt telescopes — 8-inch, 18-inch, and 48-inch — is sweeping the sky to pick up objects of special interest, such as supernovae.

A Pittsburgh amateur, C. R. Raible, is to be credited with the proposal which has now been adopted to make December 13th Russell W. Porter day. The Caltech optical expert is to be honored in various ways on that date, when amateurs all over the country are invited to send him expressions of good will.

According to Albert "Unc" Ingalls, of "Telescoptics" fame, amateurs made at least 30,000 roof prisms (and maybe 60,000, if a report from Texas is true) during the war. This achievement is especially noteworthy since at one time roof prisms were a highly critical military shortage.

Among the other speakers was Dr. Duncan Macdonald, of Boston University, fresh from the first atomic bomb test at Bikini. Dr. Macdonald used cameras and spectrographs to record the brightness and spectral changes of the bomb burst. At a distance of 12 miles, the initial peak brightness appeared visually to equal that of the sun.

Dr. Macdonald invited amateurs visiting the Boston area to inspect the Optical Research Laboratory of Boston University, located at 320 Bay State Road. This project, at which many amateur telescope makers work, was begun in the early days of the war at Harvard Observatory. It grew to very large proportions, carrying on optical design and construction, chiefly of aerial camera lenses and mounts, for both the National Defense Research Committee and the Air Corps. It has been transferred to Boston University as a continuing Army peacetime project.

Others who spoke briefly were Dr. John Strong, of Johns Hopkins University; David O. Woodbury, author of **The Glass Giant of Palomar**; Dr. James G. Baker, wartime director of the Harvard optical project mentioned above; and Dr. George Z. Dimitroff, of Dartmouth University. Drs. Baker and Dimitroff are the joint authors of the book, **Telescopes and Accessories.**

An unusual feature of the evening was provided by Dr. Donald H. Menzel, of Harvard, who showed a motion picture of the Climax coronagraph and of Bernard Lyot's pictures of prominences on the sun.

ASTRONOMICAL ANECDOTES

(Continued from page 9)

Make a disk that is the same apparent size as the horizon moon and paste it on the mirror. Later, when the moon stands high, look at it again in the mirror, and you will find that again it appears to be of the same size as the disk. But when the horizon moon is viewed without the mirror it appears larger than the disk. This is an example of pure illusion which can not be overcome by any effort of the intellect.

R.K.M.

THE BEAUTY AND MYSTERY OF THE NORTHERN LIGHTS

(Continued from page 5)

across the gap if a beam of ultraviolet radiation is flashed upon it.

A question is often asked, "Why is the auroral corona seen just south of the zenith by observers widely separated, even hundreds of miles apart?" First, we must take into consideration the continuous action producing the aurora. The corona is not the same one, even for the same observer, from one minute to the next. It is a continuing phenomenon. A cloud apparently hanging on the side of a mountain is not the same cloud from one minute to the next — it is not composed of the same water particles, for these pass on with the wind as new ones take their place. The moist air, cooled as it comes across the ridge, supplies a stream of material to keep up the continuing phenomenon. Similarly, converging rays of the aurora maintain the corona. Also, coronal activity takes place in a relatively thin shell of the earth's atmosphere, the lower part of which is usually 60 miles or more above the surface. Particles from the sun passing through this shell incite the luminosity only during the time they are within this limited region. The rays are bent toward a converging point, opposite to the direction of the earth's magnetic pole, and are sensibly parallel for observers at different locations not too widely separated.

Observers at different locations have a limited range of vision and see the luminous rays produced in the shell of atmosphere overhead. The observable phenomena at one place are very similar to those at another place, although exactly the same portion of the shell is not seen. In other words, observers at two different places do not see the same virtual corona but very similar apparent ones. The rainbow is somewhat analogous; different rays of sunlight and different drops of water produce similar apparent rainbows for two observers, who, however, may be widely separated and not seeing the same virtual rainbow.

The predominant green color of the auroral light is due to a strong band at wave length 5577.35, attributed to oxygen, which radiation is always present though rather faint in the ordinary night sky. Other colors are produced by lines and bands in different parts of the spectrum. These are chiefly due to oxygen and nitrogen, the two most abundant elements of the atmosphere in which we live and move and have our being. So the beauty and mystery of the aurora are linked with the deeper mysteries of life itself.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

The Visibility of the Planets — IV

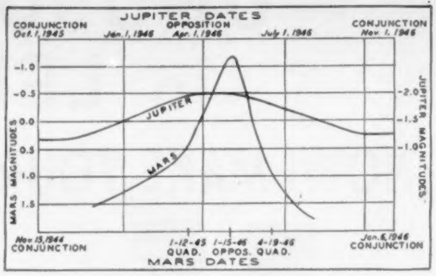
JUPITER, the giant planet, has only small variations of magnitude as compared with Mars. As seen on the graph, the vertical or magnitude scale is the same for both planets but in a different position for Jupiter. The horizontal or time scale for Jupiter is 13 months across while Mars' is 26, so Jupiter's time scale is half that of Mars. At conjunction, Jupiter is about —1 magnitude, so if other conditions are favorable the planet may be seen shortly before or after conjunction. This year the planet will be south of the sun and not easy to see a month or more before the actual conjunction the end of October. But the ecliptic position will be favorable for northern observers after conjunction. By the 15th of November, 16 days past conjunction, Jupiter can be seen before sunrise..

The reverse situation will be true in six years, when the giant planet will be north of the sun in Pisces or thereabouts, and it can be followed until 15 days before conjunction.

At opposition Jupiter may be of magnitude —2.0 to —2.5. Oppositions in April are the poorest because the planet is at aphelion; this year was just such a case. September is the time of brightest oppositions, for Jupiter is then at perihelion, and 47 million miles closer to the sun.

Between conjunctions Jupiter can be followed for 11 months or 11½ months at most.

Saturn, farthest and slowest moving of the naked-eye planets, takes 29½ years to make one revolution about the sun. Yearly, Saturn has small variations of brightness amounting to about two thirds



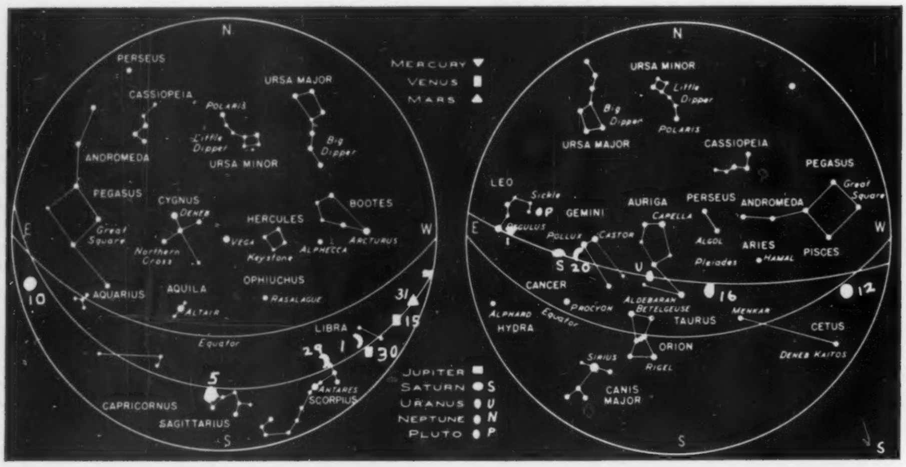
Brightness changes of Mars and Jupiter. This chart also appeared here last month. The dates for Mars should be corrected to read 10-12-45 for the first quadrature and Jan. 6, 1947, for the last conjunction.

of a magnitude, but over a long period the total change may be two magnitudes. This is partly due to the eccentricity of the planet's orbit, whereby Saturn may be 100 million miles closer to the earth at opposition at perihelion than at aphelion. The main factor, however, is the planet's rings, depending on their apparent width as viewed from the earth. At fullest view, the rings account for 70 per cent of the total brightness. This was the case two years ago, and now the rings are slowly closing, as we see them. At that time, Saturn's magnitude was —0.3 at opposition. The brightest it ever becomes is —0.4, at oppositions in Sagittarius, but because of the low declination such events are not favorable for Northern Hemisphere observers. The other good opposition occurs in Taurus, high in the sky for observers in north latitudes, as in 1944.

When the rings are edge-on or invisible, as will be the case in 1951, the opposition magnitude may be +0.6 to +0.9. Near conjunction under such conditions Saturn may be as dim as +1.5. This year it ranges from —0.2 to +0.5. Thus, when near the sun, Saturn is zero or 1st magnitude, making it easy to view. This year and for some years to come conditions are good. The ring planet could be seen in the morning sky about three weeks after the July 21st conjunction. After this, 10½ months will elapse before Saturn disappears into the evening twilight. Slight optical aid always helps greatly in watching objects a short distance from the sun, because your sight is concentrated to a small area.

The visibility of the stars can be considered in somewhat the same fashion as we have discussed the various planets in this series of articles. Unlike planets, the stars do not appear to move among themselves, and only the variable stars change in brightness. Stars 20 degrees or more north of the ecliptic (not the equator), such as Arcturus, Vega, Capella, Deneb, and Altair, can be seen by mid-northern observers some time every night in the year. Only stars near to or south of the ecliptic disappear for some time for an observer north of the equator on the earth. The reverse is true south of our equator, and stars like those above mentioned disappear from view for quite a period. Bright stars on the ecliptic or nearby become invisible to all observers on the earth (except at a total eclipse) for a period of from six to nine weeks each year, depending on the position of the sun with

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 5:30 a.m. local time on the 7th of the month, and at 4:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and 6:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury passes superior conjunction on the 14th; hence it will not be visible all month.

Venus reaches greatest elongation on September 8th, 46° 17′ east of the sun. This is an unfavorable elongation for observers in mid-northern latitudes; the planet sets about 1½ hours after the sun. Telescopically, Venus' phase is like that of a quarter moon. The planet can be seen in the daytime; it is on the meridian about 2:45 p.m. local time. Use binoculars to find it first; when its location is known Venus may be seen with the naked eye. Faster-moving Venus will pass 3½° south of Jupiter on the evening of September 3rd.

Earth will reach heliocentric longitude 0° on the 23rd at 15:41 GCT. The sun will cross the celestial equator to the south, autumn beginning in the Northern Hemisphere; spring in the Southern.

Mars can be seen in eastern Virgo after sunset. Some optical aid may be required to pick it up. It will pass 1° above Jupiter on the 25th; with a clear southwest horizon the pair may be seen a half hour after sunset.

Jupiter is slowly moving away from the vicinity of Spica and can be seen only shortly after sunset. By locating the planet early in the month and fixing the point where it sets with a landmark, it may be possible to follow Jupiter until October.

Saturn rises four hours before the sun on September 15th. Its stellar magnitude is +0.5, the same as Procyon 20° to the south.

Uranus remains between Beta and Zeta Tauri; it rises some time before midnight and is of the 6th magnitude.

Neptune cannot be seen as it is a short distance from the sun. E. O.

regard to them. From New York, Aldebaran can be seen three weeks before, and three weeks after the sun passes it. Antares cannot be seen for eight weeks when near the sun. Stars south of the ecliptic become invisible for much longer periods between when they are last seen in the evening and first seen in the morning. Sirius cannot be seen from New York for three months from mid-May until mid-August. Observers in Cape Town can look at Sirius every night in the year.

Therefore, the time a star can be seen is dependent completely on the observer's latitude, the star's angular distance from the sun, and the star's magnitude — a brighter star can be seen closer to the sun than can a dim one.

EDWARD ORAVEC

A NEW COMET

The Harvard clearinghouse received on August 8th a cablegram from New Zealand reporting the discovery of a new comet of the 9th magnitude. Its position on August 6.8 was 7^h 56^m, —13° 15', its motion 3^m east and 15' south per day. It was discovered by A. Jones, a variable star observer of Timaru, New Zealand.

OCCULTATION PREDICTIONS FOR SEPTEMBER

2-3 **84 B Scorpii** 6.3, 16:11.3 —20-58.3, 7, +70° +24° Im: **F** 4:13.9 ... ... 172°; **G** 2:57.0 —1.4 —1.3 120°; **H** 3:11.4 —2.0 —2.2 142°.

8-9 **37 Capricorni** 5.8, 21:31.8 —20-19.6, 13, +70° +21° Im: **G** 4:55.6 —1.6 +0.6 87°; **H** 4:35.5 —2.2 +0.4 104°; **I** 4:40.5 —1.5 +1.0 84°.

14-15 **38 Arietis** 5.2, 2:42.0 +12-13.2, 19, +82° —5° Em: **A** 6:26.0 —1.5 +1.2 252°; **B** 6:27.8 —1.6 +1.0 261°; **C** 6:14.4 —1.5 +1.4 252°; **D** 6:16.8 —1.5 +1.1 266°; **E** 5:55.7 —1.4 +1.0 278°; **F** 5:36.9 —0.9 +1.1 267°.

16-17 **129 H^1 Tauri** 5.7, 4:35.1 +20-34.7, 21, +90° +28° Em: **A** 4:58.9 ... ... 172°; **B** 5:11.3 +0.7 +3.1 190°; **C** 4:49.1 ... ... 167°; **D** 5:09.7 +0.6 +2.7 196°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, a and b quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5 — E +91°.0, +40°.0
B +73°.6, +45°.6 — F +98°.0, +30°.0
C +77°.1, +38°.9 — G +114°.0, +50°.9
D +79°.4, +43°.7 — H +120°.0, +36°.0
I +123°.1 +49°.5

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the American Ephemeris and Nautical Almanac and the British Nautical Almanac, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

VARIABLE STAR MAXIMA

These predictions of variable star maxima are made by Leon Campbell, recorder of the A.A.V.S.O., Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

September 4, T Ursae Majoris, 7.9, 123160; 5, T Hydrae, 7.7, 0850**08**; 9, R Canum Venaticorum, 7.7, 134440a; 11, R Sagittarii, 7.2, 1910**19**; 21, RR Sagittarii, 6.6, 1949**29**; 23, R Leporis, 6.7, 0455**14**; 26, R Leo Minoris, 7.2, 093934. October 6, T Cassiopeiae, 7.8, 001755.

MINIMA OF ALGOL

September 1, 5:31; 4, 2:19; 6, 23:08; 9, 19:56; 12, 16:45; 15, 13:34; 18, 10:22; 21, 7:11; 24, 4:00; 27, 0:48; 29, 21:37. October 2, 18:25; 5, 15:14.

A WIDESPREAD AURORA

(Continued from page 11)

sations that were absent at first increased and by 10:50 p.m. EDT the sky was so bright I could easily read my watch. At 11:00, a very bright red spot appeared in the east. At 12:00, when I last observed, there were some dim streamers in the west.

WILLIAM GRANT TIFFT
Seymour, Conn.

On July 27th, at approximately 4:30 a.m. EDT, I observed an auroral display of rare form and beauty, although, from its appearance, I missed seeing it at its best. It was like a spiral curtain, greenish-white, with the northernmost edge of the spiral most brilliant. The remainder of the spiral flickered rapidly so as to make its true form visible for only short periods at a time.

JOHN HUMPHRIES
Belvidere, N. J.

The tremendous northern hemisphere group of sunspots transited July 26th. I counted 94 spots in this group alone with a 3-inch refractor.

At 12:30 a.m. EST, July 27th, I observed a brilliant aurora. Rays resembling searchlights converged directly upon Deneb. No corona was seen, however, the rays simply meeting at the star and fading out beyond. The color was a very pale gray-blue. Shortly before 12:50, a rapid undulatory movement commenced—giving the appearance of great transverse waves moving up the sky to the zenith. Rapid and varied changes took place in quick succession.

At 2:10 the aurora was much more brilliant, and the center had shifted to east-northeast. There were fugitive tints of yellow and red. At 2:40 all the arcs observed 30 minutes earlier had vanished. In their place was a broad, elliptical arc, with a rapid pulsation.

JAMES C. BARTLETT, JR.
Baltimore, Md.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown. To convert standard time to daylight saving time, add one hour.

VESTA AT OPPOSITION

The brightest asteroid, Vesta, reaches opposition to the sun on September 22nd, when its magnitude will be about 6.6. The following positions are all in Cetus, and are taken from the **Handbook** of the British Astronomical Association.

Date		Hrs.	Min.	°	'	Mag.
Aug.	24	0	38.0	—07	26	6.7
Sept.	1	0	34.0	—08	24	6.6
	9	0	28.5	—09	25	6.6
	17	0	21.9	—10	25	6.6
	25	0	14.6	—11	20	6.6
Oct.	3	0	07.3	—12	04	6.6
	11	0	00.6	—12	34	6.7
	19	23	55.0	—12	50	6.8

PHASES OF THE MOON

First quarter ...... September 3, 14:49
Full moon .... September 11, 9:59
Last quarter .... September 18, 6:44
New moon .... September 25, 8:45
First quarter .... October 3, 9:53

Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.; Tuesdays and Fridays, 8:00 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

September: THE STORY OF THE PLANETS. In telling the history of man's knowledge of the solar system, we celebrate the anniversaries of the discovery of Neptune and the birth of Tycho.

October: THE MIDNIGHT SUN.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

September: YARDSTICK OF THE GODS. The story of how astronomers plumb the vast depths of space, and of the cosmic "yardstick" used in measuring the unimaginable distances to stars.

October: COLORS IN THE SKY.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

September: TYCHO, THE STAR-GAZER. The 400th anniversary of the birth of Tycho will be commemorated with the story of his work and his influence. Planetary motions will be emphasized.

October: COMETS AND METEORS.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Friday and Saturday, 3 and 8:30 p.m.; Sunday at 3, 4:15, and 8:30 p.m.

STAFF: *Director,* Dinsmore Alter (on military leave). *Acting Director,* C. H. Cleminshaw. *Other lecturer:* George W. Bunton.

September: HOW TO RECOGNIZE THE STARS. Simple ways to learn the constellations, the stars visible at different seasons and at different latitudes, outlines of mythological figures among the stars, will be shown.

October: THE MILKY WAY.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.: Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Edward H. Preston.

September: FRONTIERS OF THE SKY — GREAT DISCOVERIES. This month we will demonstrate how man's ideas of the universe have expanded and been revised through the centuries.

October: AUTUMN CONSTELLATIONS.

In Focus

THIS MONTH'S Plate VIII in the moon series brings us again to the southern side of the first-quarter moon, continuing northward around the limb. Not included in the original seven prints received from Lick Observatory, this and the following plate of the series, together with two additional prints to go with the last-quarter series, were kindly supplied by J. F. Chappell, of that observatory. A total of nine plates will complete the first-quarter moon.

On the key chart, as in former months, all the named features of the moon are located. At this phase, identification of features near the limb is very difficult, and hence such objects are shown only in their approximate positions and sizes. Spellings follow the International Astronomical Union's **Named Lunar Formations,** by Blagg and Mueller, and bibliographical information is from the British Astronomical Association publication, **Who's Who in the Moon.** Some features on this month's back cover will also be found in Plate I and II of the series, with discussion in the In Focus columns for February and March of this year.

Adams. A ring plain with broken walls, named for John Couch Adams, co-discoverer of Neptune, and director of Cambridge Observatory. (See page 7 of this issue.)

Behaim. A walled plain near the lunar limb. Martin Behaim (1436-1506) made the famous Nuremberg globe, finished in 1492, which depicted the known world before the discovery of America.

Biot. A small, bright crater near Mare Foecunditatis.

Borda. A ring plain with high walls and a central peak. Named for an 18th-century naval officer and astronomer.

Hecataeus. Named for the first of the great Greek geographers; he lived some 500 years before Christ.

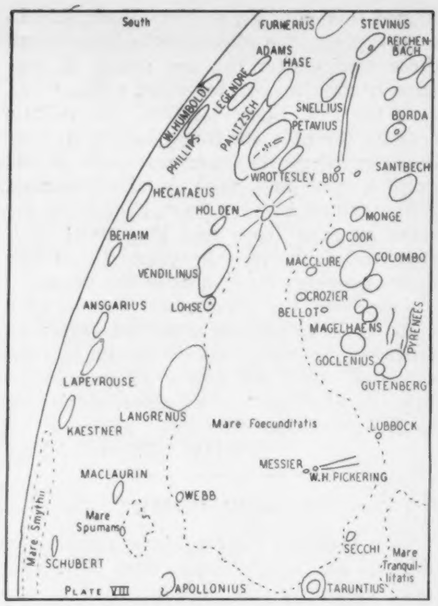
Holden. Edward Singleton Holden was born 100 years ago. After serving at the U. S. Naval Observatory and Washburn Observatory, he planned Lick Observatory, becoming its first director.

W. Humboldt. This walled plain is named for the brother of Alexander von Humboldt, for whom Mare Humboldtianum is named. W. Humboldt is described by Goodacre as being a circle 130 miles in diameter, made very elliptical through foreshortening. Some of its walls rise to 16,000 feet.

Langrenus. This 80-mile walled plain would compare with Copernicus if well placed on the moon, according to Goodacre. It has a complex central mountain and a bright floor. It is named for a 17th-century astronomer at the court of Philip IV. He engraved on copper a map of the full moon, the first that had names of the formations.

Legendre. Although 46 miles in diameter, this formation shows poorly at this phase. Legendre was a very famous 18th-century French mathematician and geometer.

Maclaurin. Colin Maclaurin was professor of mathematics at Aberdeen at the age of 19. He later succeeded Gregory at Edinburgh and developed Newton's fluxions, with many solutions of astronomical problems. He died just 200 years ago.



Mare Foecunditatis. The Sea of Fertility is the largest in the western half of the moon, and appears in its entirety on this chart.

Mare Smythii. This sea on the moon's limb is named for an admiral in the British navy who fought Napoleon and then surveyed the Mediterranean. Amateurs know him as the compiler of the **Cycle of Celestial Objects,** with a list of double and multiple stars, clusters, and nebulae observed by himself. He died in 1865.

Mare Spumans. The Foaming Sea, but not labeled as such or mentioned in Goodacre's description in **Splendour of the Heavens.**

Monge. A peddler's son who made good as a professor of mathematics at Paris University. He was with Napoleon in Egypt, and was the first to explain the mirages seen there.

Palitzsch. Named for a German farmer of the 18th century, first to observe the return of Halley's comet on December 25, 1758.

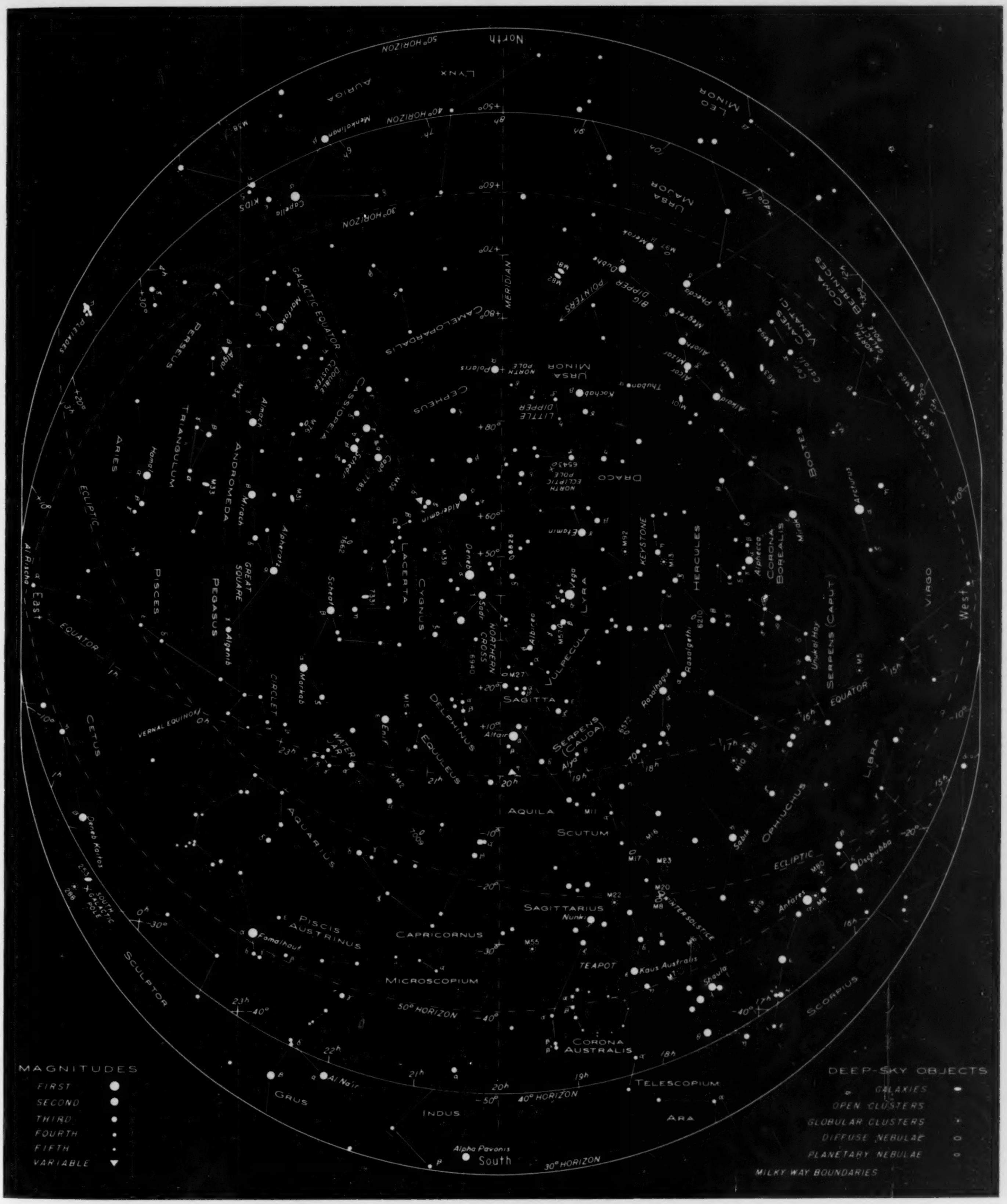
Petavius. In some places, the walls of this complex formation are double. It is 100 miles long and contains a mountain 5,000 feet high.

Santbech. This formation is 42 miles in diameter, its eastern walls rising to 15,000 feet above the interior. Named for a 16th-century Dutch mathematician and astronomer.

Vendilinus. This irregular formation has many craters and ringed plains associated with it. It is named for a Belgian astronomer of the 17th century who determined a solar parallax of 14 seconds of arc.

Webb. The author of **Celestial Objects for Common Telescopes** is commemorated by this small crater on the border of Mare Foecunditatis. He lived from 1806 to 1885.

Wrottesley. This ring adjoins Petavius, and is named after Baron John Wrottesley, an amateur astronomer who rose to become president of the Royal Society. He published numerous astronomical papers and two star catalogues.



DEEP-SKY WONDERS

DURING THIS MONTH the wonderful areas of Cygnus are overhead. Sweep along the Milky Way with binoculars or a rich-field telescope; with a power of 20x on a 6-inch R.F.T. the dark nebulosities are plainly evident.

Vulpecula. NGC 6853, M27, the Dumbbell nebula. $19^h\ 57^m.4$, $+22°\ 35'$. One of the great show objects of the sky. Visible in a finder, but seen better in a 10-inch 60x than in a 6-inch rich-field. Its planetary nature is not easily evident.

Lyra. NGC 6720, M57, the Ring nebula. $18^h\ 52^m.0$, $+32°\ 58'$. The great smoke ring, between Gamma and Beta Lyrae and hence easily located. In extent 60″ x 80″, it requires at least 50x, and 100x on a 13-inch is needed to do it justice.

Scutum. NGC 6705, M11, the "wild duck flight." $18^h\ 48^m.2$, $-6°\ 20'$. Brilliant, even against the rich background of the Milky Way. Increases in aperture merely reveal unsuspected complexity and depths.

WALTER SCOTT HOUSTON

STARS FOR SEPTEMBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.